DOCUMENT RESUME

ED 460 265 CE 077 665

TITLE	Michelin Tire Company Workplace Literacy Curriculum.
INSTITUTION	Alabama State Dept. of Education, Montgomery.
SPONS AGENCY	Office of Vocational and Adult Education (ED), Washington, DC. National Workplace Literacy Program.
PUB DATE	1996-00-00
NOTE	154p.
CONTRACT	V198A40030
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	Adult Basic Education; Curriculum Guides; Inplant Programs; Instructional Materials; Learning Activities; Learning Modules; Lesson Plans; Literacy Education; *Mathematics Instruction; Mathematics Skills; *Measurement; *Measurement Equipment; *Metric System; *Numeracy; Reading Comprehension; *Statistical Analysis; Student Evaluation; Workplace Literacy
IDENTIFIERS	*Statistical Process Control

ABSTRACT

This packet provides generic versions of curriculum developed for the Michelin Tire Corporation workplace literacy program, specifically the mathematics portion. Altered material included in the packet protects proprietary information; some lessons include lines that take the place of deleted information. Other companies are recommended to use their own nomenclature to fill in these areas. The 11 lessons adapt easily for use by the individual student or in a classroom group setting. Each lesson consists of some or all of the following components: lesson summary sheet with job title, lesson title, overall time, and the following information in a table format--specific instructional objective and learning activities with corresponding time, resources/materials, and evaluation process; teacher's outline of content and activities; videotape script(s); handout(s); transparency masters; worksheet(s); worksheet answer key(s); and post-assessment. Lesson topics are as follows: measuring using the metric ruler; lapsed time (downtime calculations); reading gauges; measuring with a Vernier caliper; reading comprehension (keeping up with change in the workplace); statistical process control (SPC)--measuring accurately; SPC--recording measurements on SPC charts; SPC--calculating average; SPC--calculating range; SPC--recording average and range; and SPC--plotting average and range. (YLB)

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ED 460 265

Michelin Tire Company
Workplace Literacy Curriculum

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Mr. Fred Blackwell
Personnel Manager
Michelin Tire Corporation
P.O. Box 40
Dothan, Alabama 36302

January 13, 1996

Dr. Bobby Dees
Coordinator Adult Education Program
State Board of Education
Gordon Persons Building
50 N. Ripley Street
Montgomery, Alabama 36104-3833

Dear Dr. Dees,

We have reviewed the Michelin Tire Company, US4 generic curriculum. There is no proprietary information included and we authorize the State Department of Education to use it for distribution to other National Workplace facilities as deemed appropriate.

Sincerely,

Fred Blackwell

Mrs. Barbara Turner
Instructor
Michelin Tire Corporation
P.O. Box 40
Dothan, AL 36302

November 1, 1995

Mr. Randel Walker, Project Director
National Workplace Literacy Program
P.O. Box 2000
Hanceville, AL 35077-2000

Dear Randel,

The enclosed lessons are the generic versions of our curriculum. The altered material included in this packet protects proprietary information. Some of the lessons include lines that take the place of deleted information. We recommend that other companies use their own nomenclature to fill in these areas.

Lessons included in this packet are:

Measuring Using the Metric Ruler

Lapsed Time (Downtime Calculations)

Reading Gauges

Measuring With a Vernier Caliper

Reading Comprehension (Keeping Up With Change in the Workplace)

SPC - Measuring Accurately

SPC - Recording Measurements on SPC Charts

SPC - Calculating Average

SPC - Calculating Range

SPC - Recording Average & Range

SPC - Plotting Average & Range

The lessons we are unable to forward because they are exclusively Michelin-specific are:

Reading a Product Ticket & Matching it to a Consigne

Understanding Tolerance

Reading a Rubber Plaque

Completing a CQ Ticket

Reading a Computer Menu

As the Instructor, I have found the lessons to be very easy to apply, and the students are extremely receptive to them. This material adapts easily for use by the individual student or in a classroom group setting. We hope that these curricula will incorporate successfully for application at other sites.

Sincerely,

Barbara Turner

Barbara Turner

Measuring Using The Metric Ruler

Module: Job Specific Tasks (WSI)
Job Title: Operator
Lesson: Measuring Using the Metric Ruler

Overall Time: 70 Minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
Upon completion of this lesson, the student will be able to measure with 100% accuracy.	10 mins	1.1 **Motivational Activity** Show video tape of student and instructor arguing the importance of using the metric ruler. Video also includes information on how the metric system has been adopted by most of the industrialized nations.	Metric Measurement video or script Video tape player Television	
	10 mins	1.2 **Preteach Vocabulary** Instructor uses the overhead projector to give a mini-lecture on the following: meter centimeter (numbered line) millimeter (short line) end line Students label their handout and take notes.	Transparency (1.2a) Overhead Projector Handout (1.2a)	
7	5 mins	1.3 **Instructional Activity** Demonstrate measuring in millimeters and centimeters	Overhead Projector Transparency 1.2a	8

Module: Job Specific Tasks (WSI)
Job Title: Operator
Lesson: Measuring Using the Metric Ruler

Overall Time: 70 Minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
	10 mins	1.4 **Guided Practice** Divide the class into small groups or pairs and distribute worksheet. Instructor will circulate and assist.	Worksheet 1.4a Metric rulers	Review if necessary.
	10 mins	1.5 **Guided Practice** Instructor will provide actual samples from the workplace for students to measure. This will be performed in pairs with the teacher circulating to ensure understanding.	Work samples 1.5 Metric rulers	
	15 mins	1.6 **Independent Practice** Students will complete a worksheet and one book assignment.	Worksheet 1.6a *Math for the World of Work*, p. 23 Metric rulers	Answers will be checked by the instructor.
	10 mins	1.7 **Post Assessment** Student will complete.	Post Assessment 1.7	100% on Post Test indicates mastery.

Module: Metric Measurement

Job Title: Operator

Lesson: Measuring Using the Metric Ruler

Learning Objective:
Upon completion of this lesson, the student will be able to:
measure with 100% accuracy using a metric ruler.

1.1 Motivational Activity:
Show video tape, *Metric Measurement*. The video covers the importance of using the metric ruler and a brief historical perspective. It includes information on how the metric system has been adopted by most of the industrialized world.

1.2 Pre-Teach Vocabulary:
The instructor will use the overhead projector to give a mini-lecture on the following:

1. meter - a word originated form the Greek word, metron, meaning to measure. It is the fundamental unit of length in the metric system equivalent to 39.37 in.

2. centi - a word originated from the Latin word, centum, meaning hundred. A centimeter is equivalent to one-hundredth of a meter.

3. milli - a word originated from the Latin word, mille, meaning thousand. A millimeter is equivalent to one-thousandth of a meter.

The centimeter is represented by the numbered lines on the metric ruler and the millimeter is represented by the sort lines between the numbered lines. There are ten millimeters in each centimeter. There are one hundred centimeters in each meter.

The abbreviation for centimeter is cm. The abbreviation for millimeter is mm.

Handouts are distributed. The instructor labels the parts of the metric ruler on the transparency as the students label their handout of the same diagram.

1.3 Direct Instruction:
The instructor demonstrates how to measure using millimeters and centimeters. Using the transparency from the labeling exercise above, the teacher will demonstrate how to measure the lines drawn on it.

1.4 Guided Practice:

The instructor will divide the class in to small groups or pairs and distribute worksheet 1.4a. The teacher will circulate and assist. Upon completion, the class will go over the answers together.

1.5 Guided Practice:

The instructor will provide actual work samples for students to measure as they would in the workplace. This will be performed in pairs with the teacher circulating to ensure understanding.

1.6 Independent Practice/Post Assessment

Students complete the worksheet and a book assignment independently.

1.7 Post Assessment

Students with a score of 100% have achieved mastery.

References:

1992 Grolier Electronic Publishing, Inc.
Crowell, C. E., (1990). Math for the World of Work. New York: Educational Design, Inc.

METRIC MEASUREMENT SCRIPT

Teacher: Mr. Jones, today you and I are going to talk about measuring product with a metric ruler, to ensure that our tires meet specifications.

Mr. Jones: Mrs. Smith, why do I have to learn how to use a metric ruler now? I have been working here for 15 years and eyeballing the width of the product has always been good enough in the past. When you look at this product every day for 15 years, you just automatically know if it is right or not!

Teacher: Now, Mr. Jones, I understand that you can judge the width of the product, but do you think everyone in your department can do the same?

Mr. Jones: Yes! I think anyone who has been here for 15 years can look at the product and tell if it is the correct measurement.

Teacher: What about the people who have not been here 15 years? Can they do as well as you?

Mr. Jones: Well, no. There are some new hires out there that don't have the experience that I have. It will take them a while to get up to speed.

Teacher: Mr. Jones, it takes a long time to acquire the experience to judge measurements the way you do. I can show you a way to teach your new hires how to measure, using a ruler, in about 20 minutes. Wouldn't it be better to show your new hires how to measure in a short amount of time, instead of waiting for them to get the experience?

Mr. Jones: I see your point, but why do we have to use the metric system? What's wrong with using inches, feet and yards?

Teacher: There really isn't anything wrong in using the English system of measurement. However, the majority of the industrialized world is using the metric system. If we are going to be able to do business with other countries, we all need to be using the same system of measurement. As a matter of fact, metric farm machinery has been manufactured for many years in the United States, and transportation equipment, cars, engines and even beverages have all become metric. Even here in the state of Alabama, they are anticipating changing the mileage and speed limit signs to the metric system.

Mr. Jones: Mrs. Smith, that's really interesting and a little bit scary at the same time. Just imagine driving to work some morning and looking at the speed limit sign and not actually understanding what it means! Talk about a Twilight Zone experience! I guess I'd better wake up and smell the coffee. Things are changing, and I need to keep up with the changes.

Teacher: I know what you mean. It's a challenge, but it sure makes life interesting.

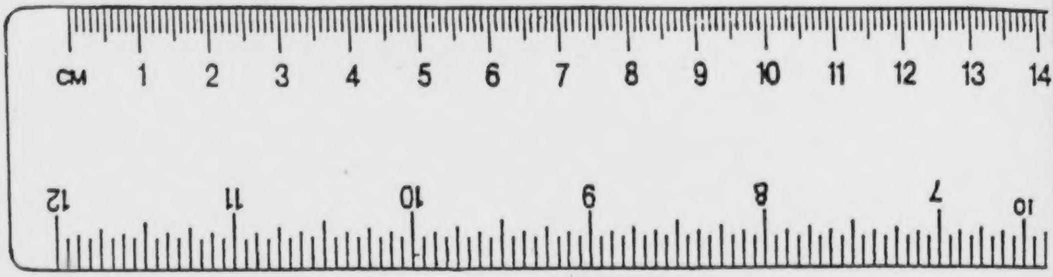
Mr. Jones: Can you really teach me about the metric ruler in just 20 minutes?

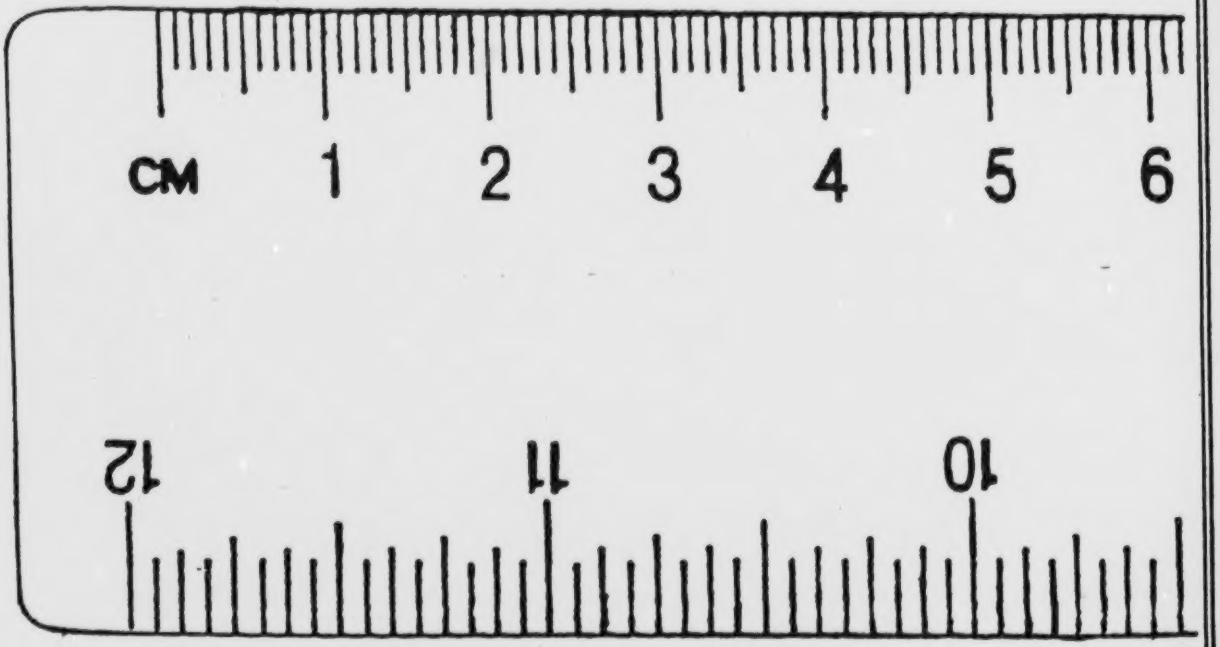
Teacher: Sure, let's start right now!

Handout 1.2a

Measuring With Centimeters and Millimeters

Metric Ruler: Actual size


CM
1
2
3
4
5
6
7
8
9
10
11
12
13
14
12
11
10
9
8
7
10


CM
1
2
3
4
5
6
12
11
10

Metric Ruler: Increased 310%

Metric Measurement Worksheet - 1.4a

Measure the following lines in Centimeters (cm) and millimeters (mm).

EXAMPLES:

________________________ 6 cm. 60 mm

__________________ 4.4 cm. 44 mm

EXERCISES:

1. _________ _____ cm _____ mm

2. __________________________________ _____ cm _____ mm

3. __________________ _____ cm _____ mm

4. __________________________ _____ cm _____ mm

5. ____ _____ cm _____ mm

Answer Key

Metric Measurement Worksheet - 1.4a

Measure the following lines in Centimeters (cm) and millimeters (mm).

EXAMPLES:

________________________ 6 cm. 60 mm

__________________ 4.4 cm. 44 mm

EXERCISES:

1. _________ 2.3 cm 23 mm

2. __________________________________ 8.6 cm 86 mm

3. __________________ 4.5 cm 45 mm

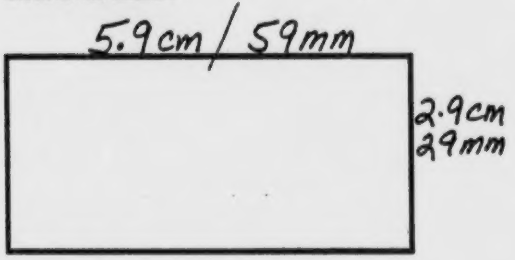
4. ___________________________ 6.5 cm 65 mm

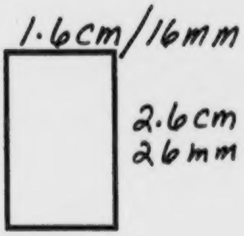
5. ____ 11 cm 110 mm

Metric Measurement Worksheet - 1.6a

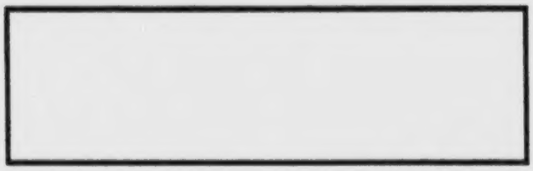
Using the metric ruler, measure the dimensions of the following figures:

EXAMPLES:


5.9cm / 59mm
2.9cm
29mm


1.6cm/16mm
2.6cm
26mm

1.



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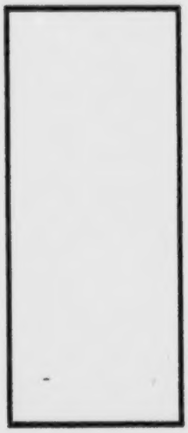
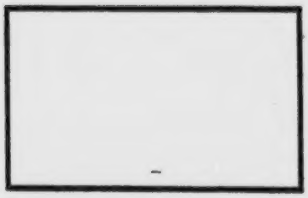


2.



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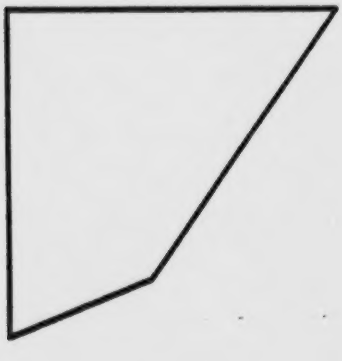
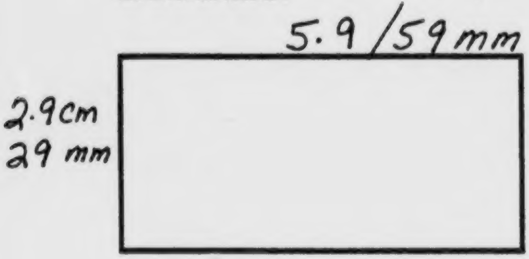


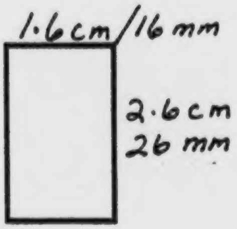
Answer Key

Metric Measurement Worksheet - 1.6a

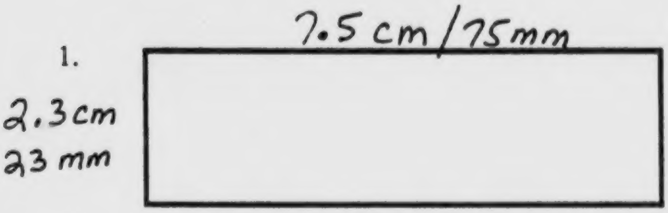
Using the metric ruler, measure the dimensions of the following figures:

EXAMPLES:

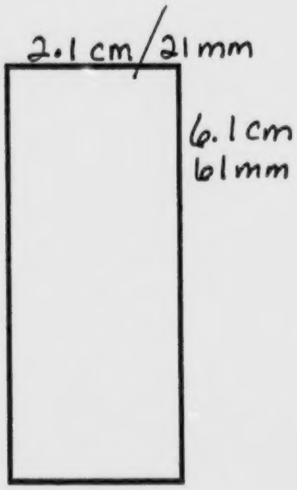

5.9 / 59 mm
2.9cm
29 mm


1.6cm / 16 mm
2.6 cm
26 mm

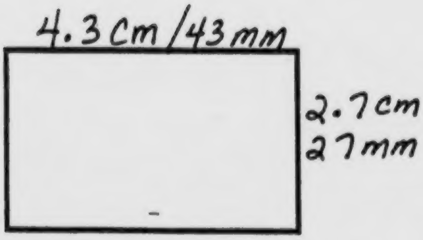
1.


7.5 cm / 75mm
2.3cm
23 mm

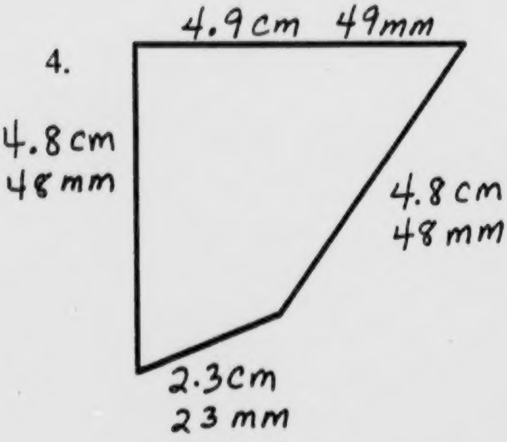
3.


2.1 cm / 21mm
6.1cm
61mm

2.


4.3 cm / 43 mm
2.7cm
27mm

4.

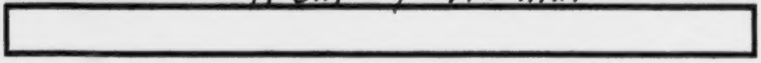

4.9 cm 49mm
4.8 cm
48 mm
4.8 cm
48 mm
2.3cm
23 mm

Metric Measurement Post - Assessment - 1.7

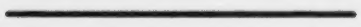
Using the metric ruler, measure the following in millimeters:

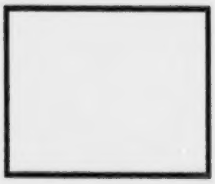
EXAMPLE:

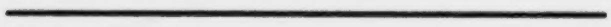
11 cm / 110 mm

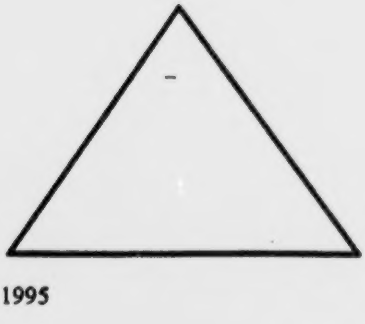


.8 cm / 8 mm

1. 

2. 

3. 

4. 

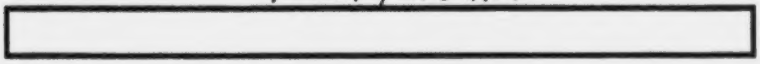
MICHELIN
TRAINING

Answer Key

Metric Measurement Post - Assessment - 1.7

Using the metric ruler, measure the following in millimeters:

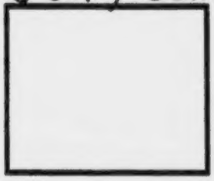
EXAMPLE: 11cm / 110mm



.8cm /8mm

1. 5cm 50mm

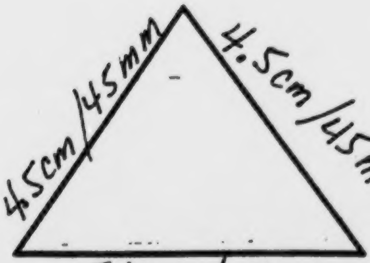
2. 3cm / 30mm



2.5cm
25mm

3. 8.8 cm / 88 mm

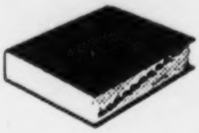
4.



4.5cm / 45mm

4.5cm / 45mm

5.1cm / 51mm



Literacy Skills

LESSON: Measuring With the Metric Ruler

- Recognizing common words and meanings, task-related words with technical meanings, and meanings of abbreviations and acronyms.
- Identifying factual details and specifications within text, following sequential directions to complete a task.
- Selecting parts of text or visual materials to complete a task.
- Using measuring devices to determine an object's length, width, and height.

Calculating Lapsed Time

(Downtime)

Module: Job Specific Tasks (WSI)
Job Title: Opeerator
Lesson: Calculating Lapsed Time (Downtime)

Overall Time: 1 hour 30 minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
Student will be able to calculate lapsed time with 100% accuracy.	10 mins.	1.1 Motivational Activity Instructor leads a discussion about keeping track of lapsed time in our daily lives.	Dry erase board	
	10 mins.	1.2 Preteach Vocabulary Discuss definitions.	Dry erase board	
	30 mins.	1.3 Direct Instruction Instructor demonstrates different methods used to calculate lapsed time.	Dry erase board	
	15 mins.	1.4 Guided Practice Students work in pairs to complete worksheet.	Worksheet 1.4 Dry erase board	Class discusses answers.
	15 mins.	1.5 Independent Practice Students complete worksheet individually.	Worksheet 1.5a Worksheet 1.5b	Instructor checks each student's work.
	15 mins.	1.6 Post Assessment Students complete the post assessment.	Post Assessment 1.6	Instructor checks. Score of 100% indicates mastery.

Module: Job Specific Tasks (WSI)

Job Title: Operator

Lesson: Calculating Lapsed Time (Downtime)

Learning Objective:
Upon completion of this lesson, the student will be able to calculate lapsed time with 100% accuracy.

1.1 Motivational Activity:

Teacher leads a class discussion asking the question, "when can it be very important for us to keep track of exactly how much time has passed?" Some answers may include:

- timesheet for work - downtime
- renting a car
- paying a baby-sitter
- figuring out arrival time for traveling

1.2 Pre-Teach Vocabulary:

Discuss the definitions of:

1. A.M.
2. P.M.
3. Military time

1.3 Direct Instruction:

Teacher demonstrates the different methods for calculating lapsed time. This will include:

- Reasoning
- Military time
- Regular time

1.4 Guided Practice:

Teacher will distribute worksheet to class. Students will complete the worksheet in pairs.

1.5 Independent Practice:

Teacher will distribute a worksheet for each student to complete individually. After an introduction to the report form students complete the Downtime Report.

1.6 Post Assessment

The student will complete the final worksheet and the instructor will check. Mastery is 100%.

1.7 Additional Resources

Students complete the Uniformity Machine Downtime Reporting Sheet.

Lapsed Time Worksheet 1.4

I. Match the times: (Draw a line between the two times that mean the same thing.)

8:00 A.M.	1730 Hours
12:00 Noon	0800 Hours
5:30 P.M.	12:00 P.M.
Midnight	12:00 A.M.
3:45 P.M.	1545 Hours

II. Answer the following questions:

1. Jane rented a car at 2:30 P.M. Saturday and returned it at 10:45 A.M. Sunday. How many hours and minutes did she rent the car?

2. Ralph started work at 7:30 A.M. and worked until 8:15 P.M. How many hours and minutes did he work? He is allowed 8 hours of regular work time. How many hours and minutes of overtime did he work?

3. Jane hired a baby-sitter for her daughter. She started working at 5:05 P.M. and completed work at 1:15 A.M. How many hours and minutes did she work?

Answer Key

Lapsed Time Worksheet 1.4

I. Match the times: (Draw a line between the two times that mean the same thing.)

8:00 A.M.	1730 Hours
12:00 Noon	0800 Hours
5:30 P.M.	12:00 P.M.
Midnight	12:00 A.M.
3:45 P.M.	1545 Hours

II. Answer the following questions:

1. Jane rented a car at 2:30 P.M. Saturday and returned it at 10:45 A.M. Sunday. How many hours and minutes did she rent the car?

20 hours 15 min.

2. Ralph started work at 7:30 A.M. and worked until 8:15 P.M. How many hours and minutes did he work? He is allowed 8 hours of regular work time. How many hours and minutes of overtime did he work?

4 hours 45 min.

3. Jane hired a baby-sitter for her daughter. She started working at 5:05 P.M. and completed work at 1:15 A.M. How many hours and minutes did she work?

8 hours 10 min.

Calculating Lapsed Time - Worksheet 1.5 a

I. Answer the following questions:

1. Your machine breaks down at 3:25 A.M. and you restart it at 6:15 A.M. How long was your machine out of operation?

2. Your machine stops at 8:05 P.M. and you restart it at 2:15 A.M. How long was your machine out of operation?

3. Your machine stops at 6:25 A.M. and you restart it at 1:05 P.M. How long was your machine out of operation?

4. Your machine stops at 12:25 A.M. and you couldn't get it operational for 3 hours and 25 minutes. When did you start it up again?

5. Your machine stops at 2:15 P.M. and you restart it at 1:05 A.M. How long was your machine out of operation?

Calculating Lapsed Time - Answer Sheet 1.5 a

I. Answer the following questions:

1. Your machine breaks down at 3:25 A.M. and you restart it at 6:15 A.M. How long was your machine out of operation?

2 hours, 50 minutes

2. Your machine stops at 8:05 P.M. and you restart it at 2:15 A.M. How long was your machine out of operation?

6 hours, 10 minutes

3. Your machine stops at 6:25 A.M. and you restart it at 1:05 P.M. How long was your machine out of operation?

6 hours, 40 minutes

4. Your machine stops at 12:25 A.M. and you couldn't get it operational for 3 hours and 25 minutes. When did you start it up again?

3:50 A.M.

5. Your machine stops at 2:15 P.M. and you restart it at 1:05 A.M. How long was your machine out of operation?

10 hours, 50 minutes

Calculating Lapsed Time - Worksheet 1.5 b

I. Using the following information, compute the amount of time each machine was out of operation.

1. Your machine (42) was stopped for a belt change at 3:48 P.M. and started back up at 4:30 P.M.

2. Hillary Clinton had to turn off her machine (28) for PM at 2:30 A.M. and started it back up at 5:15 A.M.

3. George Bush turned off his machine (17) for an Intervention at 8:20 A.M. and started it back up at 10:00 A.M.

4. Bill Clinton turned off his machine (1) for a lunch break at 10:30 A.M. and didn't start it back up until 12:45 P.M.

5. Ross Perot stopped his machine (00) for a dimension change at 11:52 P.M. and turned it back on at 2:15 A.M.

Calculating Lapsed Time - Worksheet 1.5 b

I. Using the following information, compute the amount of time each machine was out of operation.

1. Your machine (42) was stopped for a belt change at 3:48 P.M. and started back up at 4:30 P.M.

42 min.

2. Hillary Clinton had to turn off her machine (28) for PM at 2:30 A.M. and started it back up at 5:15 A.M.

165 min. / 2 hrs. 45 min.

3. George Bush turned off his machine (17) for an Intervention at 8:20 A.M. and started it back up at 10:00 A.M.

100 min. / 1 hr. 40 min

4. Bill Clinton turned off his machine (1) for a lunch break at 10:30 A.M. and didn't start it back up until 12:45 P.M.

135 min. / 2 hrs. 15 min

5. Ross Perot stopped his machine (00) for a dimension change at 11:52 P.M. and turned it back on at 2:15 A.M.

143 min. / 2 hrs. 23 min.

Calculating Lapsed Time - Worksheet 1.6

I. Answer the following questions:

1. Your machine stops at 3:10 A.M. and you restart it at 7:40 A.M. How many hours and minutes was your machine out of operation?

2. Your machine stops at 11:20 P.M. and you restart it at 2:10 A.M. How long was your machine non-operational?

3. Your machine has been out of service for 6 hours and 5 minutes. It stopped at 2:15 P.M. What time did it become operational again?

4. Your machine stops at 4:05 A.M. and you restart it at 11:55 A.M. How long was your machine out of operation?

5. How many hours and minutes did you work today if you started at 6:45 A.M. and stopped at 2:30 P.M.?

Calculating Lapsed Time - Answer Sheet 1.6

I. Answer the following questions:

1. Your machine stops at 3:10 A.M. and you restart it at 7:40 A.M. How many hours and minutes was your machine out of operation?

4 hours, 30 minutes

2. Your machine stops at 11:20 P.M. and you restart it at 2:10 A.M. How long was your machine non-operational?

2 hours, 50 minutes

3. Your machine has been out of service for 6 hours and 5 minutes. It stopped at 2:15 P.M. What time did it become operational again?

8:20 P.M.

4. Your machine stops at 4:05 A.M. and you restart it at 11:55 A.M. How long was your machine out of operation?

7 hours, 50 minutes

5. How many hours and minutes did you work today if you started at 6:45 A.M. and stopped at 2:30 P.M.?

7 hours, 45 minutes

Reading Gauges

Module: Job Specific Tasks
Job Title: Operator
Lesson: Reading Gauges

Overall Time: 1 hour 15 minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
1. Be able to write the readings for several gauges.	5 min	**1.1 Motivational Activity** Distribute handout. Read as students follow. Discuss gauges used in the workplace.	Handout 1.1	
	15 min	**1.2 Pre-Teach Vocabulary** Distribute copies of the text and answer sheets. Read and discuss p. 120. Complete Guided Practice and Applied Practice p. 120.	Text: Essential Skills for the Workplace-Level One: Obtaining Information and Using Resources p. 120	Instructor and students discuss answers.
	45 min	**1.3 Direct Instruction, Guided practice and Independent Practice** Using the text, p. 122, discuss gauge reading. The class completes Guided Practices together. The class completes Applied Practices independently. This process is completed for pages 124-129.	Text: Essential skills for the Workplace-Level One: Obtaining Information and using Resources p. 122-129.	Instructor and students discuss answers.
	10 min	**1.4 Evaluation** Students complete the evaluation.	Evaluation 1.4	Instructor checks for mastery.

Module: Job Specific Tasks

Job Title: Operator

Lesson: Reading Gauges

Learning Objective:

Upon completion of the lesson, the student will be able to write the readings for various gauges with 100% accuracy.

1.1 Motivational Activity:

Distribute Handout 1.1. Read while students follow along.

The fast pace of living we experience in the 90's creates pressure. Many families depend on two incomes, just to make ends meet. In addition to the hours spent working, there are many hours spent doing other important, necessary activities. These activities include caring for a family, maintaining a home, attending community meetings, and attending church. We are constantly moving! There seems to be little time for fun and relaxation, but it is doubtful this will change. Too bad we can't measure the pressure we are under and get paid for it!

There are other types of pressure we use in our daily lives that can actually help us function. We use water pressure in our showers and air pressure in our car tires. These types of pressure can be measured.

Today, we will study some of the ways we measure pressure in the workplace. We will also study methods of measuring temperature and levels.

Ask the students what types of pressure they measure in their work area and discuss.

1.2 Pre-Teach Vocabulary:

The instructor distributes copies of the text and the answer sheets. Students and instructor read and discuss *Understanding Gauged Measurement* on page 120. The class completes the *Guided Practice* on page 121 with the instructor. The students complete *Applied Practice 1*, page 121, independently. The instructor circulates to offer assistance. The instructor and class review the answers.

1.3 Direct Instruction, Guided Practice, and Independent Practice:
(These sections are usually listed separately, but this lesson is more easily followed by combining them.) Using the same text, students turn to page 122 and follow along as the instructor explains how to read the gauges. The *Guided Practice* on page 123 is completed and discussed as a group. *Applied Practice 2* is completed independently and the answers are discussed. The instructor circulates to offer assistance. This process is repeated for pages 124-129.

The Additional Resources section, at the end of the lesson, offers another assignment. The assignment can be used when needed in the lesson. It explains how to read different scales in a step by step manner and it is especially useful to students who do not readily understand this process. Many practice exercises are available.

1.4 Evaluation:
The students complete pages 119 and 130. The instructor checks for mastery.

Additional Resources:
Introduce Math for the World of Work when appropriate. Work through pages 60-69 using the method described in 1.3.

Task 3a and 3b from the original WSI Curriculum.

References:

Crowell, C. E. (1990). Math for the World of Work (pp. 60-69). New York: Educational Design, Inc.

Mains, K.M. (1993). Essential Skills for the Workplace, Level One: Obtaining Information and Using Resources (p. 119-130). Chicago: Contemporary Books.

READING GAUGES

HANDOUT 1.1

The fast pace of living we experience in the 90's creates pressure. Many families depend on two incomes just to make ends meet. In addition to the hours spent working, there are many hours spent doing other important, necessary activities. These activities include caring for a family, maintaining a home, attending community meetings, and attending church. We are constantly moving! There seems to be little time for fun and relaxation, but it is doubtful this will change. Too bad we can't measure the pressure we are under and get paid for it!

There are other types of pressure we experience every day that actually help us function. We use water pressure in our showers and air pressure in our tires. These types of pressure can be measured.

Today, we will study some of the ways we use and measure pressure in the workplace. We will also study methods of measuring temperature and levels.

Applied Practice 2 **p. 123**

Acceptable Range 100–200 psi			
Checklist	Reading	Yes	No
Point A			
Point B			
Point C			

Guided Practice **p. 124**

1. _____F, _____C

2. _____F, _____C

3. _____F

4. _____F

Applied Practice 3 **p. 125**

Time	Thermostat Setting	Actual Temperature
1. 7:45 A.M.	A. 325°F	A.
2. 9:45 A.M.	B. 375°F	B.
3. 2:15 P.M.	C. 450°F	C.

Guided Practice **p. 126, 127**

1. B. ____ kPa

2. D. _____ psi

3. C. _____ psi

4. E. _____ kPa

5. F. _____ psi

6. B. _____ kPa

Applied Practice 4 p. 127

1. A. ______ psi

B. ______kPa

C. ______psi

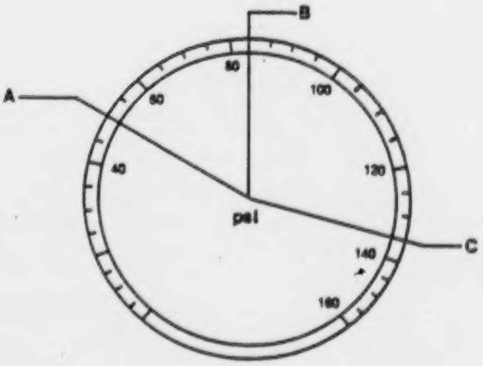
D. _____psi

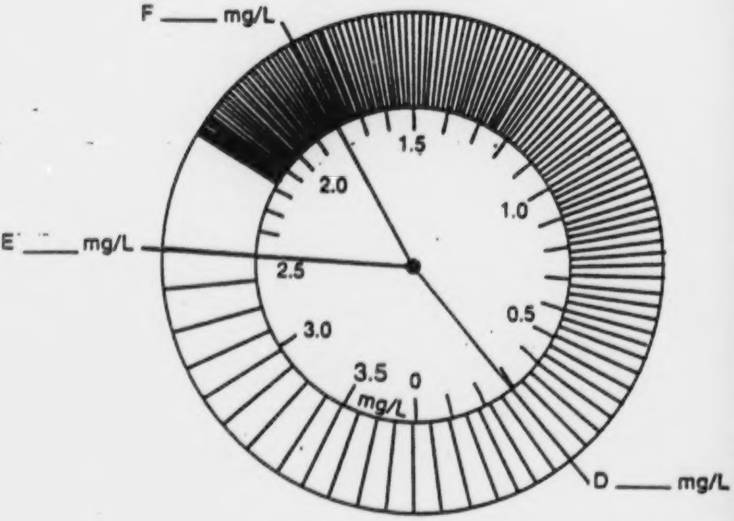
E. ______psi

F. _____kPa

2. A B C D E F

Guided Practice p. 128


A
B
C
40
60
80
100
120
140
160
psi


F ____ mg/L
E ____ mg/L
D ____ mg/L
1.5
2.0
1.0
2.5
0.5
3.0
3.5
0
mg/L

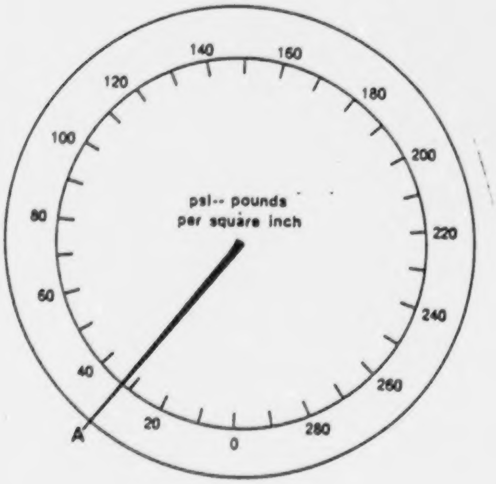
Applied Practice p. 129

1. A. ______
2. B. ______
3. C. ______
4. D. ______
5. E. ______
6. F. ______

Reading Gauges - Answer Sheet

Evaluation 1.4

Skill Preview p. 119


140
160
120
180
100
200
80
220
60
240
40
260
20
280
0
psi-- pounds per square inch
A

Skill Mastery p. 130

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________
7. ________________

Reading Gauges
Answer Key

Guided Practice p. 121

1. level
2. pressure
3. temperature
4. thickness
5. pressure

Applied Practice p. 121

1. a. pressure
2. d. thickness
3. c. level
4. b. temperature
5. b. temperature

Guided Practice p. 122, 123

	TANK A	TANK B
1.	300 psi	160 psi
2.	10 psi	5 psi
3.	220 psi	70 psi

Applied Practice 4 p. 127

1. A. ______ psi

B. 4,350 kPa

C. 150 psi

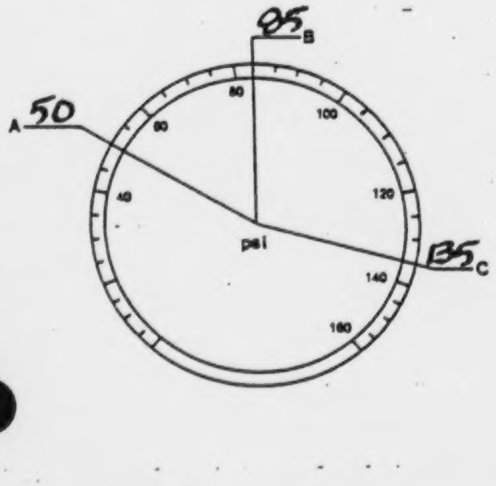
D. 100 psi

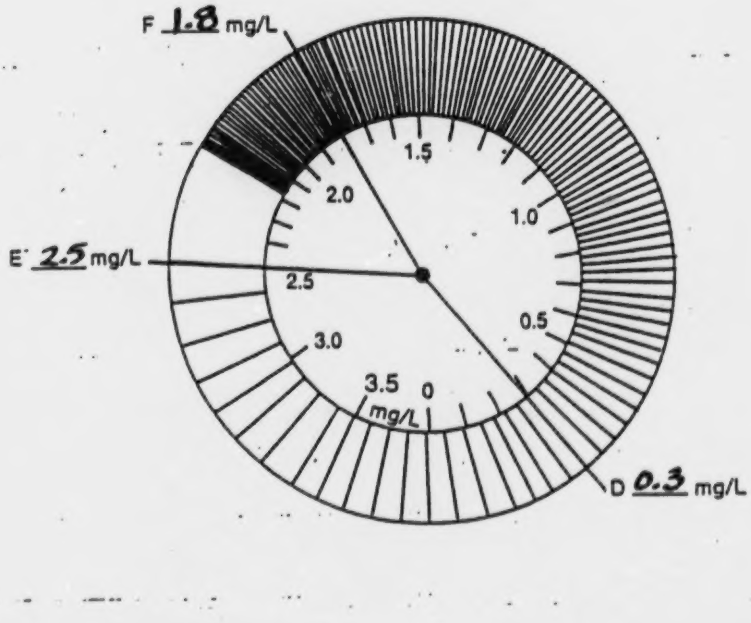
E. 800 psi

F. 40 kPa

2. A B [✓ C] [✓ D] [✓ E] F

Guided Practice p. 128


A 50
95 B
135 C
40
60
80
100
120
140
160
psi


F 1.8 mg/L
E 2.5 mg/L
D 0.3 mg/L
1.5
2.0
1.0
2.5
0.5
3.0
3.5
0
mg/L

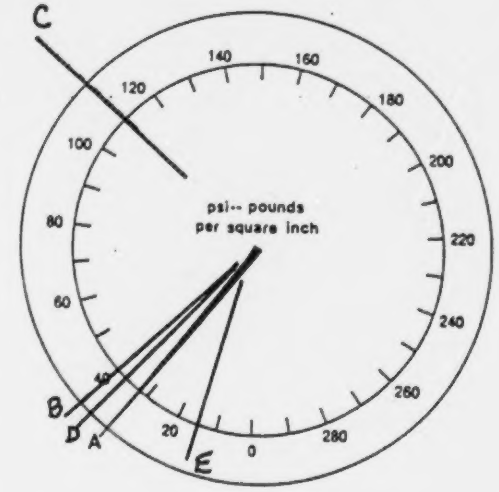
Applied Practice p. 129

1. A. 0.2
2. B. 2.1
3. C. 1.4
4. D. 0.7
5. E. 3.05
6. F. 1.9

Reading Gauges - Answer Sheet

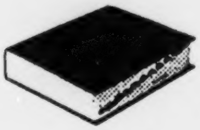
Evaluation 1.4

Skill Preview p. 119


C
140
160
120
180
100
200
psi-- pounds per square inch
80
220
60
240
40
260
B
D
A
20
0
280
E

Skill Mastery p. 130

1. 1 psi
2. 10 psi
3. 15 psi
4. 19 psi
5. 28 psi
6. 15-30 psi
7. B, C, D



Literacy Skills

LESSON: Reading Gauges

- Recognizing common words and meanings, task-related words with technical meanings, and meanings of abbreviations and acronyms.
- Identifying factual details and specifications within text.
- Selecting parts of text or visual materials to complete a task.
- Classifying or matching items by color, size, or significant markings.
- Distinguishing between relevant and irrelevant information in text or visuals
- Reading and writing decimals to one or more places to complete a task.
- Reading numbers or symbols from time, weight, distance, and volume, measuring scales and gauges.
- Reading, writing, and counting single and multi-digit numbers to complete a task.

Measuring With A Metric Vernier Caliper

Module: Job Specific Tasks (WSI)
Job Title: Operator
Lesson: Measuring with a Metric Vernier Caliper

Overall Time: 1 hour 25 minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
1. Measure with 100% accuracy using aVernier Caliper.	10 mins	**1.1 Motivational Activity** Distribute cards with caliper settings to 1\2 of the students. Distribute cards with caliper readings to remaining students. Have students mingle and try to match Their reading or setting card to the appropriate reading or setting card.	Caliper setting cards. Caliper reading cards.	
	15 mins	**1.2 Pre-Teach Vocabulary** Distribute handbook. Discuss definitions in text and labeled diagram. Pass metric Vernier Caliper around the room.	Tools and Rules for precision Measuring p. 27 L.S. Starrett Company Metric Vernier Caliper	
	10 mins	**1.3 Direct Instruction** Using the handbook, explain how to read a Metric Vernier Caliper. Use a caliper to demonstrate several measurements.	Tools and Rules for Precision Measurement p.30 L.S. Starrett Company	
	15 min	**1.4 Guided Practice** Distribute the work sheet. Read several measurements with students.	Handout 1.4	

Module: **Job Specific Tasks (WSI)**
Job Title: Operator
Lesson: Measuring with a Metric Vernier Caliper

Overall Time: 1 hour 25 minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
		Assist students when necessary.		Discuss the correct answers.
	15 mins	**1.5 Independent Practice** Have students complete the worksheet.	Continue with Handout 1.4	Instructor discusses correct answers.
	10 mins	**1.6 Guided Practice** Divide students into groups. Allow them to measure several items and record measurements.	Handout 1.6	Instructor checks answers.
	10 mins	**1.7 Post-Assessment** Instructor distributes the post-assessment	Post-Assessment 1.7	Instructor checks for mastery.

Module: Job Specific Tasks (WSI)

Job Title: Operator

Lesson: Measuring With a Metric Vernier Caliper

Learning Objective:
Upon completion of the lesson, the learner will be able to:
Measure with 100% accuracy using metric Vernier Caliper

1.1 Motivational Activity:

Distribute cards with the caliper settings to one half of the students. Distribute cards with caliper readings to the remaining one half. Students mingle and try to find the person with the reading or setting card that matches their reading or setting card. Some students may know how to read the caliper. Some may not. Those who do can assist those who don't. The instructor can check to confirm a match, but the purpose is exposure to caliper settings and readings, not correct answers. If they are unable to make a correct match, the instructor can come back to the cards after the lesson and allow students to match correctly.

1.2 Pre-Teach Vocabulary:

Distribute the L.S. Starrett Tools and Rules for Precision Measuring, handbook. Discuss the definitions in the text and labeled diagram, found on page 27. This is a general discussion of the parts of the Vernier Caliper. It is helpful to include brief historical information. It is not necessary to discuss the last two paragraphs on page 27.
Show a metric Vernier Caliper, pointing out each part. Pass the caliper around the room.

1.3 Direct Instruction:

Using the handbook, page 30, explain how to read a metric Vernier Caliper. Demonstrate how to use the caliper by measuring several items in the room, explaining as you measure. If you have students who would like to try measuring in front of the group, allow them to do so.

1.4 Guided Practice:

Distribute the worksheet. Read several measurements with the students.

1.5 Independent Practice:
Have the students complete the worksheet. Some students will need assistance. When students have completed the sheet, go over the correct answers.

1.6 Guided Practice:
Divide students into groups. Have several items for them to measure. They will record their answers on the handout. Go over the correct answers.

1.7 Post-Assessment:
The students take the post-assessment and the instructor checks for mastery. Allow students to correct any problems they may have missed. Some may need additional practice to achieve mastery.

HANDOUT 1.6

Record Your Measurements on This Sheet

	Object:	Measurement:
1.	____________________	____________
2.	____________________	____________
3.	____________________	____________
4.	____________________	____________
5.	____________________	____________
6.	____________________	____________

Reading Comprehension

Module: Reading Skills
Job: Operator
Lesson: Reading Comprehension

Overall Time: 45 minutes

Specific Instructional Objective	Time	Learning Activities	Resources/ Materials	Evaluation Process
1. Student will be able to write 5 different tasks they are responsible for in the workplace. 2. Studentss will answer the evaluation questions with 90% accuracy.	5 min	1.1 **Motivational Activity** Show the cartoon and discuss.	Cartoon	
	10 min	1.2 **Preteach Vocabulary** Distribute the worksheet. Discuss the vocabulary. Students complete the worksheet as you discuss.	Worksheet 1.2	Discuss answers.
	10 min	1.3 **Direct Instruction** Distribute the handbook. Follow the instructions on the lesson sheet.	Handbook p.12-14.	
	5 min	1.4 **Guided Practice** Students read paragraph and discuss.	Handbook p. 14.	
	15 min	1.5 **Independent Practice** Students read remainder of chapter. Discuss. Have students write 5 tasks they do on the job.	Handbook p. 14,15. Paper	Assist in the writing process as needed.
	10 min	1.6 **Evaluation** Distribute the evaluation.	Evaluation 1.6	Check for accuracy.

Module: Reading Skills

Job Title: Operator

Lesson: Reading Comprehension

Learning Objective:
Upon completion of the lesson, the learner will be able to:

1. Write 5 different tasks for which they are responsible in the workplace.
2. Answer the questions at the end of the reading assignment with 90% accuracy.

1.1 Motivational Activity:
Show the class the cartoon of the man with many hats. Lead a discussion about the meaning of the picture. Emphasize the fact that he is trying to balance the hats, but is dropping a few. Also, emphasize the expression on his face. Ask the students if they ever feel like the man in the picture. Have individuals give examples from daily life and from the workplace that demonstrate this. Discuss the implications of this cartoon for their job.

1.2 Pre-Teach Vocabulary:
Distribute the worksheet.
Discuss the pronunciation and meaning of the following words:

Ambiguity
Uncertainty
Priorities
Vaguely
Role Clarity
Voice Mail
Radically
E-mail
Perpetual

Students complete the worksheet as the words are discussed.
Explain to the students that these words are found in the next reading lesson. They do not need to memorize their meanings. The exposure to these words before the lesson will increase their understanding as they read.

1.3 Direct Instruction:
Distribute the handbook and have the students turn to page 12. Read the highlighted sentences on pages 12 and 13 aloud. Emphasize the vocabulary words. Model effective reading comprehension skills by using metacognitive techniques. (Use references if necessary.)
Turn to page 14. Read the title aloud. Review the two vocabulary words. Read the first two paragraphs aloud. Model comprehension skills.

1.4 Guided Practice:

Have the students read paragraph 3, silently. Discuss the paragraph, asking questions to reveal their understanding.

1.5 Independent Practice:

The students read the remainder of the chapter. Briefly discuss this section. Allow students to ask questions they have from the text. Discuss different tasks for which students are responsible at work. Have them list at least 5 diffferent tasks. Remind them of the illustration shown at the beginning of the lesson.

Assist in the writing process as needed.

1.6 Evaluation:

Distribute the evaluation. After the students have completed it, check for mastery.

References:

Duffy, G.G. and Roehler, L. R. (1987). Modeling Mental Processes helps Poor Readers Become Strategic Readers.

Pritchett, P. (1994). The Employee Handbook of New Work Habits for a Radically Changing World. Dallas: Pritchett & Associates, Inc.

Reading Comprehension

Worksheet 1.2

The following vocabulary words are found in the next chapter of the handbook:

Ambiguity
Uncertainty
Priorities
Vaguely
Role Clarity
Voice Mail
Perpetual
Radically
E-mail

Read the definitions below. Place the vocabulary word on the line in front of the correct definition.

1. ____________________ Receiving messages through an automated telephone answering system.

2. ____________________ Placing responsibilities in order, according to importance. Most important one is first.

3. ____________________ Not clear or definite.

4. ____________________ Extreme or drastic.

5. ____________________ Lasting or enduring forever.

6. ____________________ Receiving messages through a computer system that is linked.

7. ____________________ Lack of clarity in meaning; the possibility of having more than one meaning.

8. ____________________ Defining responsibilities clearly.

9. ____________________ Doubt.

Reading Comprehension

Worksheet 1.2

Answer Key

The following vocabulary words are found in the next chapter of the handbook:

Ambiguity
Uncertainty
Priorities
Vaguely
Role Clarity
Voice Mail
Perpetual
Radically
E-mail

Read the definitions below. Place the vocabulary word on the line in front of the correct definition.

1. Voice Mail Receiving messages through an automated telephone answering system.
2. Priorities Placing responsibilities in order, according to importance. Most important one is first.
3. Vaguely Not clear or definite.
4. Radically Extreme or drastic.
5. Perpetual Lasting or enduring forever.
6. E-mail Receiving messages through a computer system that is linked.
7. Ambiguity Lack of clarity in meaning; the possibility of having more than one meaning.
8. Role Clarity Defining responsibilities clearly.
9. Uncertainty Doubt.

Reading Comprehension

Evaluation 1.6

Answer the following questions from pages 12-15 of The Employee Handbook of New Work Habits For A Radically Changing World.

1. List two radical changes that have occurred within the last 10 years. (From pages 12 & 13)

2. List 3 changes workers will be faced with in the new work environment.

3. What types of effects may uncertainty have on workers' attitudes?

4. What will organizations have to do to survive in the years to come?

____

____

5. In paragraph 4, the author states, "Careers won't be as cut-and-dried as they used to be. And this is not really by choice." What is causing this to happen?

____

____

6. Because of the "blur of ambiguity," you should learn to create role clarity for yourself. List 3 things you can do to create role clarity for yourself.

____

____

____

7. What is the "critical skill" referred to in paragraph 7?

____

____

8. What can you do to develop the "critical skill"?

9. What types of uncertainty are you experiencing in your work area?

10. What is the best way for you to respond to rapid change?

Reading Comprehension

Evaluation 1.6

Answer Key

Answer the following questions from pages 12-15 of The Employee Handbook of New Work Habits For A Radically Changing World.

1. List two radical changes that have occurred within the last 10 years. (From pages 12 & 13)

Any sentence except the first one.

2. List 3 changes workers will be faced with in the new work environment.

New expectations, shifting priorities, different reporting relationships, vaguely defined role, more questions than answers

3. What types of effects may uncertainty have on workers' attitudes?

People who are structured, hate it
it even bothers employees who have a high tolerance for uncertainty. People grow tired of enduring it.

4. What will organizations have to do to survive in the years to come?

change constantly

5. In paragraph 4, the author states, "careers won't be as cut-and-dried as they used to be. And this is not really by choice." What is the causing this to happen?

The rapid changes in the world dictate what organizations must do.

6. Because of the "blur of ambiguity," you should learn to create role clarity for yourself. List 3 things you can do to create role clarity for yourself.

Take personal responsibility for figuring out top priorities

Don't wait for someone else to do it

Show initiative, work fast

7. What is the "critical skill" referred to in paragraph 7?

ability to tolerate ambiguity and uncertainty

8. What can you do to develop the "critical skill"?

loosen up, prepare to feel your way along in the future, wing it, improvise, accept it

9. What types of uncertainty are you experiencing in your work area?

10. What is the best way for you to respond to rapid change?

accept the fact that things will constantly change.. (Title)

BASIC
SPC MATH

INTRODUCTION TO BASIC SPC MATH

One of the primary goals in manufacturing is to produce quality products. The manufacturer wants each product to be of the same, excellent quality. But, just as there are variations in nature and no two things are exactly alike, there are variations in products. SPC helps to reduce the variation in the manufacturing process.

Statistical Process Control is a method used to collect measured information about a product while it is on the line. The measurements are charted on a control chart. Then, a decision is made about whether or not the process is stable and running smoothly. If it is not stable, the cause is identified and certain actions are taken. SPC helps to ensure the production of quality products.

This module is designed to help the student understand the math concepts commonly found in SPC. The student will improve math skills and learn how they relate to SPC. He or she will learn more about metric measurements taken in SPC, how to record measurements, how to calculate and record averages and ranges, and how to plot averages and ranges on SPC charts. The student will have many opportunities to practice these skills.

The lessons are job-specific. This approach will help in the transfer of skills to the job and will help the learner feel that the training is relevant.

NOTES TO THE INSTRUCTOR

This curriculum has been designed to help students improve the basic math skills associated with SPC. You may use teacher-directed instruction or individualized instruction to teach these skills. Upon completion of the unit, the student will be able to calculate averages and ranges, and complete control charts.

Each lesson in the unit builds upon material presented in the previous lesson. It is beneficial for a student to complete each lesson in progression; however, with slight modifications, the lessons can be used in isolation. The instructor may find it appropriate to combine the lessons for some groups or individuals. Within each lesson, there are opportunities for practice. There are resources for additional assignments listed at the end of the lesson for those who need them.

Individuals must possess basic math skills to facilitate a grasp of SPC concepts. The pre-assessment measures the level of mastery a student has of these skills. The student will take the pre-assessment to determine readiness for the SPC module. To achieve mastery, the student will need to achieve a score of 90%. If this score is not achieved, the instructor will guide the student in making review assignment choices in their weak areas before beginning basic SPC math. When the student achieves mastery in those areas, he or she may begin SPC math. If a score above 90 is achieved, the student may take the post-assessment for mastery.

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Calculating Average

LESSON FOUR 51
Calculating Range

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Recording Average & Range

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Plotting Average & Range

PRE & POST ASSESSMENT 81

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LESSON ONE

MEASURING ACCURATELY

JOB TITLE: ____Operator
MODULE: Basic SPC Math
LESSON: Measuring Accurately (Review of metric measurement lesson)

LEARNING OBJECTIVES:

Upon completion of the lesson the student will:

1. List 3 causes of inaccurate readings.
2. List 3 ways to ensure accurate readings.
3. Measure samples of ___ accurately, using a Fowler Digital Caliper.
4. Weigh samples of ___ and _______ accurately, using a Mettler Balance.

SET INDUCTION:

The instructor places the following statement on the overhead or writes it on the board:

> "The greatest cause of error in measuring is the inaccuracy of the person using the measurement instrument."

The students are asked to discuss whether they agree or disagree with the statement and explain why.

PRE-TEACH VOCABULARY:

Review the definitions for: Fowler Digital Caliper, Mettler Balance ________, _______, Accuracy, and Calibrate.

Distribute Vocabulary sheet 1.1 for the students to complete. It has a chart with 3 columns labeled operator, instrument, and product. The student will match the operator with the correct instrument and product and write their responses on the chart. They define and write the definition on the sheet. In the 4th column, labeled calibration, they place a check if that instrument requires calibration.

LINK OLD TO NEW:
In the metric measurement lesson, the students learned to measure using metric rulers, calipers, and micrometers. They learned to weigh using the Mettler Balance. This lesson is a review of the measuring techniques used with the Fowler Digital Caliper and the Mettler Balance only, and will highlight the importance of measuring accurately for SPC.

DIRECT INSTRUCTION:
The instructor leads a discussion about using accurate measuring techniques. The following ideas should be covered:

1. The instrument must be calibrated.
2. The operator must pay attention to details.
3. The operator must take the sample correctly using the correct instrument.
4. The operator must know and follow the correct procedure for measuring with the required instrument.

The instructor discusses the 3 causes of inaccurate measuring that are:

1. Poor condition of the instrument.
2. Environmental changes such as temperature and humidity.
3. Lack of knowledge by the person using the instrument.

Ask the students to discuss which of these 7 things they can control. (They can control all but the second cause listed under inaccurate measuring.)

The instructor distributes a note sheet with these ideas listed (appendix 1.2). Students may want to add their own notes to this sheet.

The instructor may find it necessary to demonstrate measuring with each instrument as a review.

INDEPENDENT PRACTICE:

The instructor distributes samples of ________________ and ________ for the students to weigh and measure. They record their answers on the sheet provided (appendix 1.3). The samples are pre-weighed and pre-measured so answers can be checked for accuracy.

The students divide into groups for the next activity.
The instructor distributes ________________ Sampling Plan sheet and question sheet (appendix 1.4a and 1.4b). The students read and answer the questions. The answers are discussed.

POST ASSESSMENT:

The instructor gives the post assessment. (appendix 1.5)

MATERIALS NEEDED:

Vocabulary Sheet (appendix 1.1)
Notes on measuring accurately (appendix 1.2)
Sheet for recording measurements (appendix 1.3)
________________ Sampling Plan sheet (appendix 1.4a)
Question sheet (appendix 1.4b)
Post Assessment (appendix 1.5)
Pre-weighed and pre-measured samples of

ADDITIONAL RESOURCES:

Review the metric measurement lessons
Students will need to do Lesson 2 immmediately following Lesson 1.

LESSON ONE
VOCABULARY SHEET
(Appendix 1.1)

Fill in the first 3 columns on the chart using the vocabulary choices given below the chart:

Operator	Instrument	Product	Calibration
1.			
2.			
3.			

______________ ______________ Mettler Balance
______________ ______________ Fowler Digital Caliper

Define Calibrate:

____

____

Go back to the chart. Place a check in the column labeled "Calibration" beside the instruments that must be calibrated.

Notes

Measuring Accurately

(Appendix 1.2)

ACCURATE MEASURING TECHNIQUES

1. The instrument must be calibrated.
2. The operator must pay attention to details.
3. The operator must take the sample correctly using the correct instrument.
4. The operator must know and follow the correct procedure for measuring with the required instrument.

THREE CAUSES OF INACCURATE MEASUREMENT

1. Poor condition of the instrument.
2. Environmental changes such as temperature and humidity.
3. Lack of knowledge by the person using the instrument.

Which of the 7 items listed above can the operator control?

Measurement Recording Sheet

(Appendix 1.3)

As you measure and weigh the samples, record your answers in the appropriate spaces on this sheet.

MEASUREMENTS:

1. ______________________ **2.** ______________________

3. ______________________ **4.** ______________________

WEIGHTS:

1. ______________________ **2.** ______________________

3. ______________________ **4.** ______________________

WEIGHTS:

1. ______________________ **2.** ______________________

2. ______________________ **4.** ______________________

Question Sheet

(Appendix 1.4b)

Mary works as a ________ Operator. SPC methods are used at her post to control the process of cutting ___ products. She measures the width of ___ using a Fowler Digital Caliper. She records her answers on a control chart. A subgroup of measurements is taken at the beginning of each roll loaded for that dimension and on the last bobbin cut for that set-up.

Use the paragraph above, and the Sampling Plan Sheet to answer the following questions:

1. The ________ Operator measures the length or width of the (Circle correct answer)

2. When she checks the calibration of the caliper, what should the display show? (Circle correct answer)
   - A. 00.000
   - B. 000.00
   - C. 0.0000
   - D. 0000.0

3. If the caliper is not set correctly, what should she do?

4. The Fowler Digital Caliper displays_____ places to the right of the decimal. (Circle the correct answer.)

   A. 3
   B. 4
   C. 5
   D. 2
   E. 1

5. T or F When taking a measurement, the operator should apply steady, even pressure to the caliper.

6. John is in a hurry to increase his production. He wants to measure quickly, so he decides to skip the calibration step. Why is it important to calibrate the caliper? What will happen if he doesn't?

The ______________ Operators weigh samples using a Mettler Balance.

7. Does the Mettler Balance require calibration ("zeroing in")?

8. If you answered "yes" to question 7, explain what will happen if it isn't calibrated.

Post Assessment

(Appendix 1.5)

1. List 3 ways to ensure accuracy when measuring and weighing.

   1. ____
      ____
   2. ____
      ____
   3. ____
      ____

2. Define calibration. ____________________________
   ____
   ____

3. Measure and weigh the samples provided and write your answers below:

_______ Width: 1. ______________ 2. ______________

_______ Weight: 1. ______________ 2. ______________

_____ Weight: 1. ______________ 2. ______________

LESSON TWO

RECORDING MEASUREMENTS ON AN SPC CHART

JOB TITLE: ____ Operator
MODULE: Basic SPC Math
LESSON: Recording Measurements on an SPC Chart

LEARNING OBJECTIVES:

Upon completion of the lesson the student will:

1. Record measurements on an SPC Chart with 100% accuracy.
2. Explain 3 ways to ensure recording accuracy.
3. Explain 2 consequences of inaccurate recording.

SET INDUCTION:

Use the catalog and bill provided. Have the students look up the items listed and double check the prices. They will find a recording error. Allow the students to correct the error. Follow with a discussion covering the following questions:

1. How could the error have occurred? (recorder was distracted, in a hurry, didn't double check work, wasn't concerned etc.)

2. What would the additional cost to the customer have been if the mistake had not been found?

3. What is a good way to find a mistake in recording before it is too late?

4. What types of information do you record in your job?

5. What damage could a recording error in your area cause? Give examples.

PRE-TEACH VOCABULARY:

Sample	Variable
SPC	Variables Control Chart
SPC Chart	

Divide the students into groups. Distribute the vocabulary sheet (Appendix 2.1a). Distribute the glossary (Appendix 2.1b). The students will match the definitions to the words, placing the correct word choice in the blank. They will discover that there is not a definition for SPC Chart. They will need to create their own by combining definitions for SPC and control chart which are found in the glossary. They will need to add this definition to the vocabulary sheet and to the glossary.

LINK OLD TO NEW:

The students learned to measure and weigh samples in the metric measurement unit. The instructor explains that the measurements and weights taken in the metric measurement unit will be recorded on a control chart as a part of this lesson. The samples can be shown and a short review given of how they were taken. The samples include

DIRECT INSTRUCTION 1:

Introduce the variables control chart. This may be done using the overlay transparency (appendix 2.2a). Show the entire chart and explain the purpose of the chart. It is used to show when a manufacturing process needs to be corrected. Explain that a specific area of the chart is used for recording measurements. Focus on the area used for recording. If you are using the overlay transparency, show only the "sample values" section of the chart. Distribute the variables control chart (entire chart-appendix 2.2b), or the partial chart (appendix 2.2c). Either chart may be used, but some students may find it easier to use the partial chart. Distribute

the Variables Control Chart Exercise Sheet (Appendix 2.2d). Read the instructions and record two measurements as examples.
Ask the students what steps should be followed to ensure accurate recording. Have them brainstorm ideas.
Discuss the following points:

1. Use key words or symbols to find the correct section of the chart.
2. Emphasize double-checking all work.
3. Pay attention to details.
4. Concentrate/ignore distractions.
5. Write legibly.

Distribute the Note Sheet (appendix 2.2e).

GUIDED INSTRUCTION 1:
The students record the next two sample measurements. The instructor checks for accuracy.

INDEPENDENT PRACTICE 1:
The students finish recording the measurements and have them checked for accuracy.

DIRECT INSTRUCTION 2:
The _________ Operator Control Chart is introduced next. Use the overlay transparency (appendix 2.3a) to show the entire chart, then focus on the section used for recording measurements. Distribute the SPC chart (appendix 2.3b) and the sample measurement sheet (appendix 2.3c). Compare the Operator Control Chart to the variables control chart and point out the differences. Review the ________ sampling method. Remind students that X1 is the first measurement and X2 is the second measurement taken on the _____ Demonstrate by recording the first two measurements.

GUIDED PRACTICE 2:

The students record the next two measurements and the instructor checks for accuracy.

INDEPENDENT PRACTICE 2:

The students finish recording the sample measurements and have their work checked by the instructor.

DIRECT INSTRUCTION 3:

For the next activity, the students will divide into groups. The instructor explains that SPC charts may vary from one job post to another even within the same department. Copies of the control chart used by the ______________ appendix 2.4a) and the ________ Operator (appendix 2.4b) are distributed to the groups. Briefly review the sampling techniques used by the different operators. Discuss how the measurements are recorded on the two charts. Review the checklist for accurate recording (Note Sheet, appendix 2.2e).

GUIDED AND INDEPENDENT PRACTICE 3:

The instructor distributes samples of products. The students weigh them and one group member records them on the appropriate control chart. The instructor checks their work for accuracy. Then students complete the challenge assignment (appendix 2.5). The students and instructor discuss answers.

POST-ASSESSMENT:

The instructor administers the post-assessment (appendix 2.6).

MATERIALS NEEDED:

For Set Induction: Catalog and bill
Vocabulary Sheet Appendix 2.1a

SPC Glossary Appendix 2.1b
Overlay transparency of variables control chart Appendix 2.2a
Variables control chart (entire chart) Appendix 2.2b
Variables control chart (partial chart) Appendix 2.2c
Variables control chart exercise sheet Appendix 2.2d
Note Sheet Appendix 2.2e
Overlay transparency of ________ Operator Control Chart Appendix 2.3a
________________ Control Chart Appendix 2.3b
________________ Sample Measurement Sheet Appendix 2.3c
______________ Control Chart Appendix 2.4a
________________ Control Chart Appendix 2.4b
Challenge Assignment Appendix 2.5
Post-Assessment Appendix 2.6

ADDITIONAL RESOURCES:

Essential Skills for the Workplace: Level One
Obtaining Information and Using Resources p. 64, 65

Essential Skills for the Workplace: Level One
Using Forms and Documents p. 99, 100

Vocabulary Sheet

Appendix 2.1a

Place the vocabulary word on the line in front of the correct definition.

Sample	SPC Chart
SPC	Variables
Statistical Process Control	Variables Control Chart

______________________ 1. Things or qualities that can be measured to show differences.

______________________ 2. Statistical Process Control

______________________ 3. A limited number of parts or materials selected from the population to measure and to make some decisions about the population.

______________________ 4. An SPC chart that shows variations in a manufacturing process so they can be controlled.

______________________ 5. A method of monitoring a process or its output by using statistical techniques such as charts.

______________________ 6.

Glossary

(Appendix 2.1b)

Average: The value found by dividing the sum of a group of numbers by the total number of numbers in that series.

Control charts: A graphical representation of a manufacturing process. Graphs with a central line and one or two control limit lines.

Data: Facts, measurements,or information collected for charting.

Quality control: The sum of all inspection plans and actions used by a company to produce a good product.

Population: An entire group of parts being studied.

R: Symbol for range.

Range: The difference between the highest and lowest values in a group.

Reading: Measurement taken from sample(s) of parts or materials.

Sample: A limited number of parts or materials selected from the population to measure and to make some decisions about that population.

(Prounced sigma): Sum or total.

SPC (statistical process control): A method of monitoring a process or its output by using statistical techniques such as charts.

Specification: The detailed description of acceptable measurements set by the designer. If a product is made to specification, it is manufactured to meet design requirements.

Stable: Not likely to move or change.

Sum: The total of an addition problem.

$\overline{X}$ (Pronounced X Bar): The average of values in a subgroup. Symbol that represents the mean.

Variable: Things or qualities that can be measured to show differences.

Variables control chart: A graphical representation of a manufacturing process. Variables are meaured and charted. A variables control chart shows when a process needs to be corrected.

Appendix 2.2b

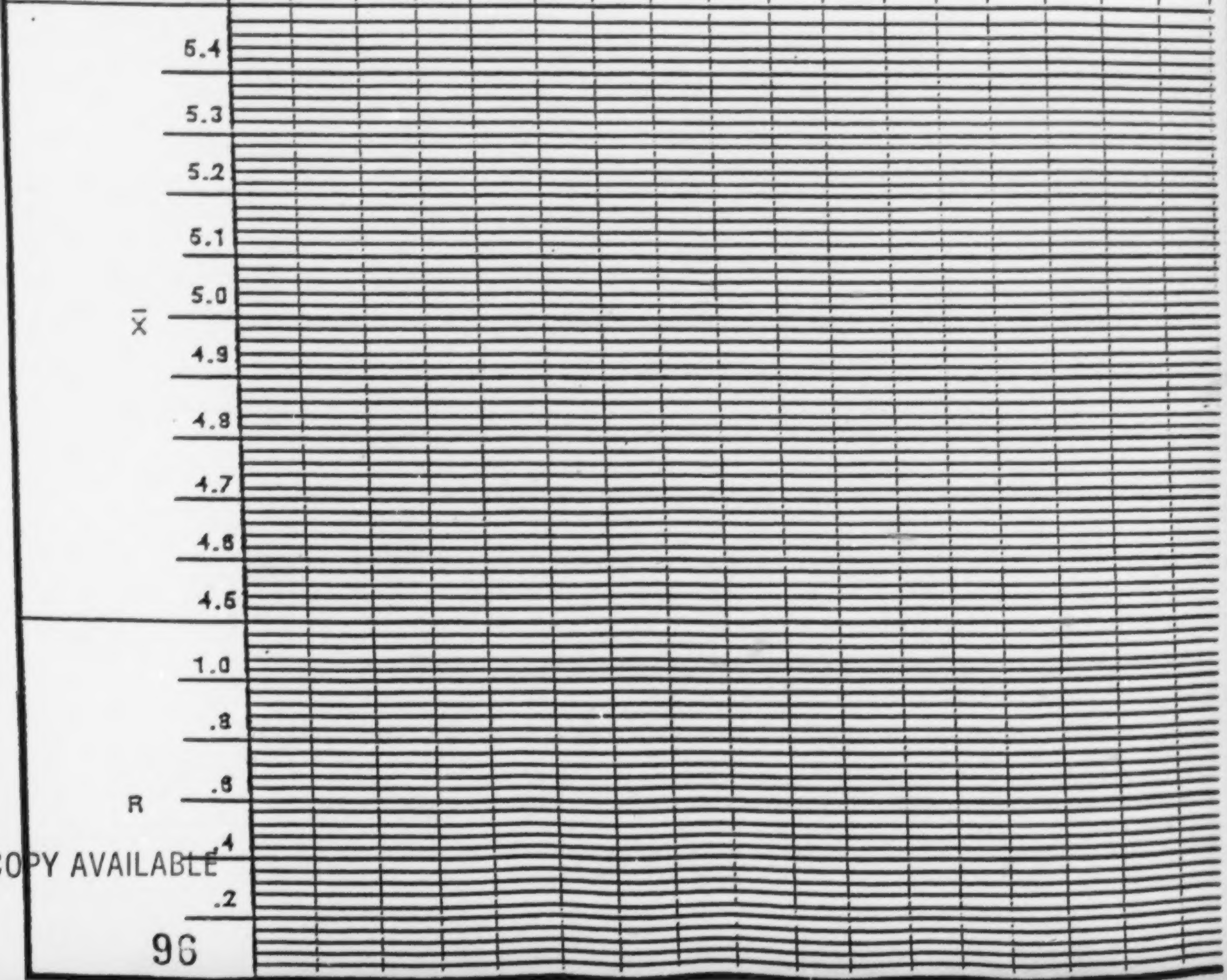
ARTICLE FABRICATION

VARIABLES CONTROL CHART

$\bar{X}$ AND R

ARTICLE		PROJECT NO. 705	OPERATOR(S)
SPECIFICATION LIMITS	5 $^{-0.5}_{+0.5}$	UNIT OF MEASURE MM	CHART START DATE

SAMPLE VALUES	1																		
	2																		
	3																		
	4																		
	SUM																		
	$\bar{X}$																		
	R																		
SAMPLE NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	1
COMMENTS																			



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Appendix 2.2C

ARTICLE FABRICATION
VARIABLES CONTROL CHART
$\bar{X}$ AND R

ARTICLE	PROJECT NO. 705	OPERATOR(S)
SPECIFICATION LIMITS 5 $^{-0.5}_{+0.5}$	UNIT OF MEASURE MM	CHART START DATE

SAMPLE VALUES	1																	
	2																	
	3																	
	4																	

RECORDING MEASUREMENTS

Variables Control Chart Exercise

(Appendix 2.2d)

You are given a blank variables control chart. At the top of the chart write the following:

1. Write your name in the blank titled "operator".
2. Write today's date in the blank titled "start date".

Let's assume that you were instructed to take measurments to record for SPC. You take these mesaurements every 30 minutes and the results are listed below:

Sample 1:	4.9	5.0	5.0	5.1	5.0	5.1	5.1	4.9	4.9	5.1
Sample 2:	4.8	5.1	5.0	4.8	5.1	5.0	5.0	5.0	5.0	4.9
Sample 3:	5.0	4.9	4.9	4.9	5.1	5.0	5.0	5.0	5.1	4.8
Sample 4:	4.8	5.0	5.0	5.0	5.1	4.9	4.9	4.9	5.1	4.8

Record these measurements in the appropriate spaces on the variables control chart.

If you are working individually, have your instructor check your work for accuracy.

Appendix 2.2d

ARTICLE FABRICATION

VARIABLES CONTROL CHART

$\bar{X}$ AND R

ARTICLE	PROJECT NO. 706	OPERATOR(S)
SPECIFICATION LIMITS 5 $^{-0.5}_{+0.5}$	UNIT OF MEASURE MM	CHART START DATE

SAMPLE VALUES	1																	
	2																	
	3																	
	4																	
	SUM																	
	$\bar{X}$																	
	R																	
SAMPLE NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COMMENTS																		

$\bar{X}$	5.4																	
	5.3																	
	5.2																	
	5.1																	
	5.0																	
	4.9																	
	4.8																	
	4.7																	
	4.6																	
	4.5																	
R	1.0																	
	.8																	
	.6																	
	.4																	
	.2																	

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Notes

Recording Measurements

(Appendix 2.2e)

TO ENSURE ACCURATE RECORDING:

1. Use key words or symbols to find the correct section of the chart.
2. Emphasize double-checking all work.
3. Pay attention to details.
4. Concentrate/ignore distractions.
5. Write legibly.

Add your notes:

RECORDING MEASUREMENTS

On A __________ Operator Control Chart

Sample Measurement Sheet

(Appendix 2.3c)

You will be given a blank copy of the SPC chart used by the ______ Operator. At the top of the chart record the following:

1. Today's date in the blank labeled DATE.
2. The product name in the blank labeled PRODUCT. The product name is
3. The ticket number in the blank labeled TICKET #. The ticket number is 62.
4. Your operator number in the blank labeled OPERATOR.

Let's assume that during B-shift you took the following measurements:

X1: 160.15 159.85 160.22 160.12 160.25 159.93 160.53
X2: 159.95 159.93 159.67 160.10 159.85 160.12 159.37

X1: 159.75 159.37 160.56 159.75 161.00 160.25 159.32
X2: 160.12 160.82 159.32 160.36 159.82 159.75 160.63

Record these measurements on the ______________ SPC chart. Have your answers checked by your instructor.

MICHELIN US4 SPC CHART

MACHINE:

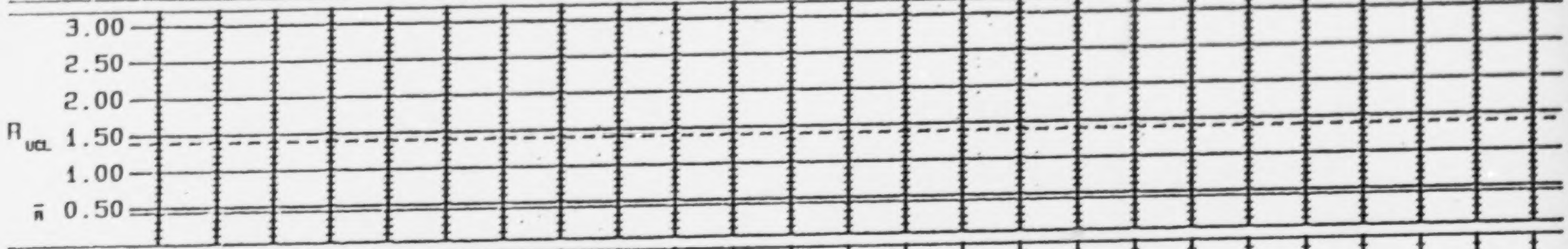
CHARACTERISTIC:

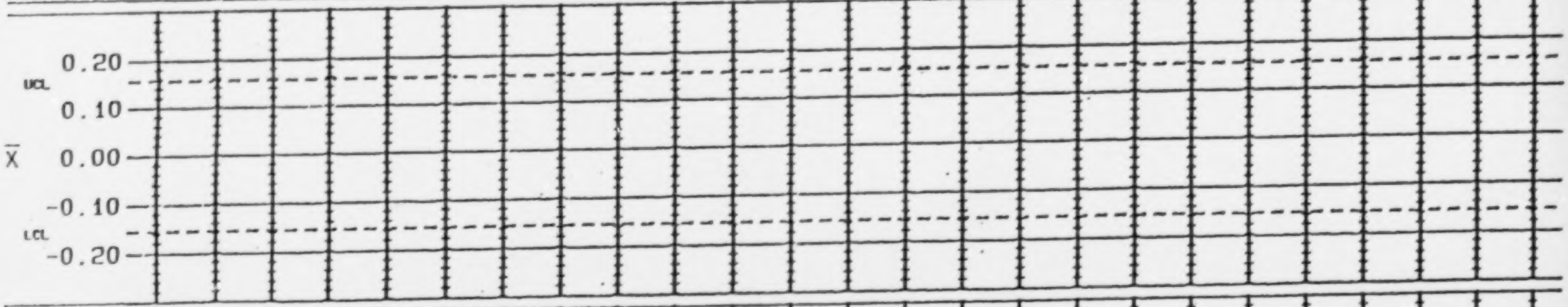
MEASURING INSTRUMENT: DIGITAL CALIPER

START-UP ZONE: MM

SPECIFICATION: MM

DATE																									
PRODUCT																									
TICKET #																									
OPERATOR																									
X_1																									
X_2																									
R																									
$\overline{X}$																									
R_x																									





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RECORDING MEASUREMENTS

Challenge Assignment

(Appendix 2.5)

Complete and accurate recording is one of the most important considerations when filling out a control chart.

1. Explain why accuracy is so important when recording samples on SPC charts. ________________________________
____
____
____

2. How can you ensure accuracy when recording samples:
____
____
____
____

3. The following group of samples has been recorded on the SPC chart. Check the recordings on the chart and circle the ones that have been recorded incorrectly.

Sample 1:	58.67	58.65	58.63	58.66	58.68
Sample 2:	58.65	58.67	58.66	58.63	58.67
Sample 3:	58.63	58.65	58.67	58.66	58.64
Sample 4:	58.62	58.67	58.68	58.65	58.66

4. During A-shift, operator 10 recorded the following weights:

   .981, .897, .972, .886.

   When she measured the 5th sample, it measured .585.

   Should she record this measurement?

   What should she do?

5. Operator 435 is new at SPC. He knows what the width of his product should measure. When the measurement is too large, he just records the closest measurement to that which would be acceptable. His thinking goes like this, "the measurement is just a little off. It won't matter if I change it".

   What do you think of this operator's choice?

   ____

   ____

   ____

   How could this effect the product?

   ____

   ____

   ____

Post-Assessment

Recording Measurement

(Appendix 2.6)

On the blank variables control chart, record the following information:

1. Write your name in the blank labeled "operator".
2. Write "5" for your machine number.
3. Record the date.
4. The following measurements were taken every hour. Record them on the control chart.

Sample 1: .983 .897 .972 .886 .986 .957 .923 .919
Sample 2: .888 .972 .983 .899 .883 .933 .930 .934
Sample 3: .986 .979 .908 .885 .982 .921 .894 .901
Sample 4: .976 .889 .984 .884 .972 .977 .949 .977
Sample 5: .986 .884 .887 .889 .893 .893 .889 .957

5. List 4 ways to ensure recording accuracy in your area:

1.____

2.____

3.____

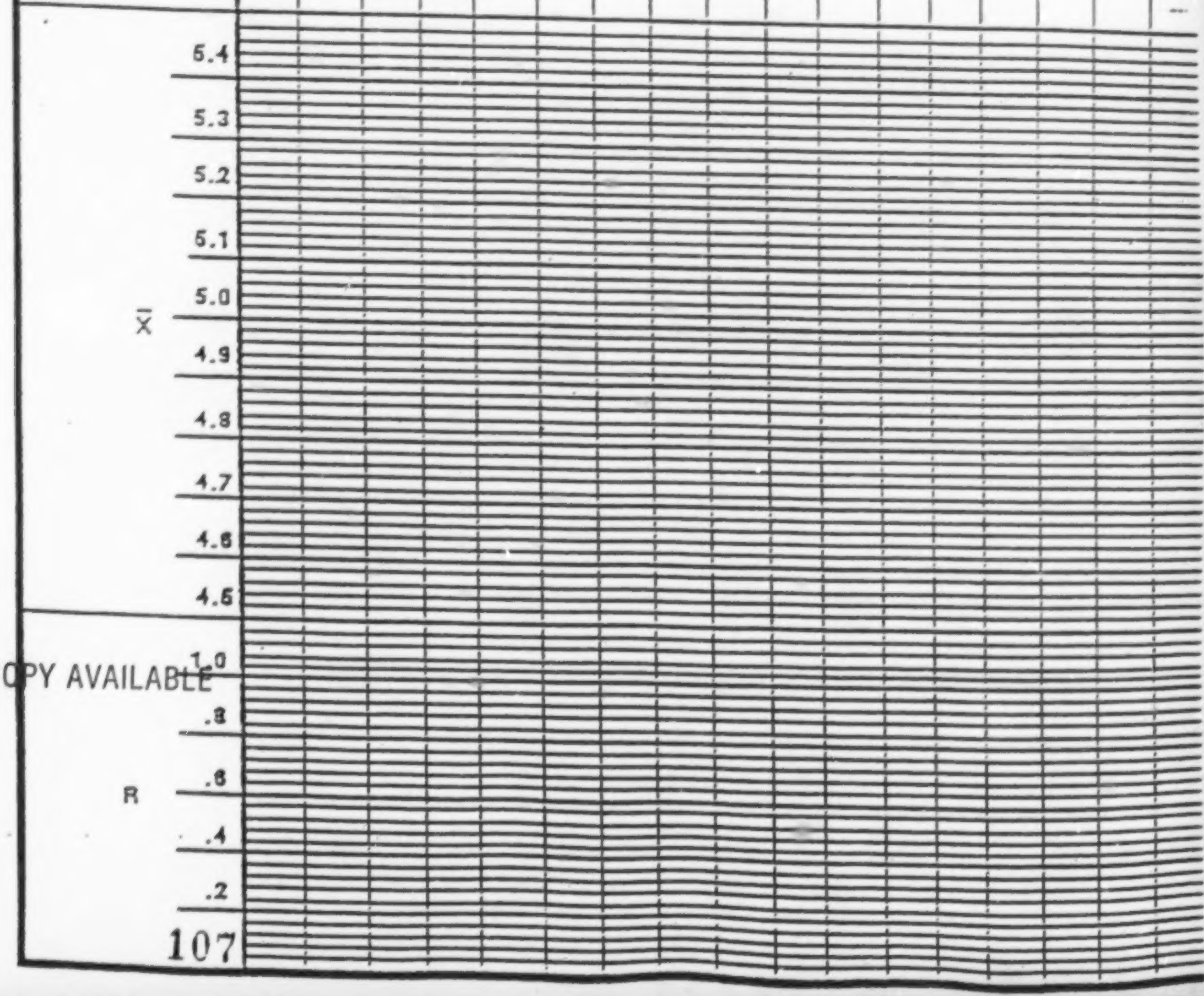
4.____

6. Explain what can happen if an operator did not record accurately. (Write your answer on the back of this sheet.)

ARTICLE FABRICATION
VARIABLES CONTROL CHART
$\overline{X}$ AND R

ARTICLE	PROJECT NO. 705	OPERATOR(S) 032
SPECIFICATION LIMITS 5 $^{-0.5}_{+0.5}$	UNIT OF MEASURE MM	CHART START DATE June 1, 199

SAMPLE VALUES	1	58.67	58.66	58.62	58.66	58.61												
	2	58.6	58.67	58.66	58.63	58.66												
	3	58.63	58.61	58.65	58.67	58.64												
	4	58.62	58.62	58.69	58.64	58.68												
	SUM																	
	$\overline{X}$																	
	R																	
SAMPLE NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COMMENTS																		



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LESSON THREE

CALCULATING AVERAGES

JOB: ____Operator
MODULE: Basic SPC Math
LESSON: Calculating Averages

LEARNING OBJECTIVES:

Upon completion of the lesson, the student will be able to:

1. Calculate averages when given a set of whole or decimal numbers, by hand, and using a calculator, with 90% accuracy.
2. Subtract the consigne width from the mean for the 10/30 Cutter operator control chart, with 100% accuracy.

SET INDUCTION:

Gather books with different numbers of pages. Place them on the table. Point out that some of the books are thick, some are thin, and some in- between. Flip to the back of each book and call out the total number of pages. Have a card inside each book with the total number of pages written on it. Fold the card in half and stand it on top on the book. Ask the students to tell which book they would choose to represent the middle value (which one has the number of pages that would fall midway between the largest and smallest values?). Make sure you have several in-between values so that it is difficult to tell which one would fall in the middle. Discuss the fact that it is difficult to tell which one represents the middle just by looking. Then explain that this lesson will be about a mathematical way to calculate which one would represent the middle value. Come back to these values later and average them as an example.

PRE-TEACH VOCABULARY:

Average, Mean, $\overline{X}$ (Xbar), Σ (sum of)

Distribute index cards with the words and symbols written on them (one per card). Discuss the fact that 3 of the vocabulary terms have the same meaning. Two of them are synonyms and one is a symbol that represents the other two. These three can be used interchangeably. The fourth term is the symbol for "sum of". The students work in groups to decide which three belong together and they place those cards together.

Pass out the vocabulary sheet (appendix 3.1) and have students read the definition of average. Assist the students in breaking the definition into 3 steps. Have them write the 3 steps on the vocabulary sheet. Have the students write the symbol for "sum of" and write the definition beside it.

LINK OLD TO NEW:

Refer to the metric measurement and recording measurement lessons. Explain that after a sample group of measurements is taken, the next step is to find the average. Using measurements like those taken and recorded in the prevlious lessons, students will calculate averages. They will look at the differences in recording averages on different SPC charts.

DIRECT INSTRUCTION 1:

Average is a good measure for the middle amount of a collection of data. The instructor will explain some of the uses for average, in general, first. This can be done by using everyday applications, for example: preparing a monthly grocery budget, averaging monthly sales of a company, averaging the number of students in a class session, averaging a student's grades, averaging temperature for a month. The instructor demonstrates calculating average using the student's 3-step method. Sample data for this can be taken from the class. The instructor could average the shoe sizes of the group, or find the average number of children among the students. Several examples can be demonstrated. Use the Additional Resource section if needed.

GUIDED PRACTICE 1:
The instructor distributes the "Sample Average Skills Practice Sheet 1" (appendix 3.2) and works several plroblems with the class They check the problems together.

INDEPENDENT PRACTICE 1:
The students complete the sheet independently and have their work checked.

GUIDED PRACTICE 2:
The instructor explains using the calculator to find averages and demonstrates several examples. Calculators and the "Sample Averages Practice Sheet 2" (appendix 3.3) are distributed and the instructor works several practice problems with the students. The answers are checked.

INDEPENDENT PRACTICE 2:
The students complete the sheet and have their answers checked.

DIRECT INSTRUCTION 3:
The instructor discusses how average is used in SPC. The instructor uses the ________ Operator SPC as an example.

The students are shown how to subtract the consigne width from the mean for recording average on this chart.

GUIDED INSTRUCTION 3:

The instructor distributes the ________ Operator's Average Skills Practice Sheet (appendix 3.4). Students work a few problems with the instructor and check their answers.

INDEPENDENT PRACTICE 3:

The students complete the sheet on their own and have their work checked. The instructor may have students work the Challenge Assignment (appendix 3.5).

POST-ASSESSMENT:

The instructor administers the post-assessment (appendix 3.6)

MATERIALS NEEDED:

Index Cards
Vocabulary Sheet Appendix 3.1
Sample Average Skills Practice Sheet 1 Appendix 3.2
Sample Average Skills Practice Sheet 2 Appendix 3.3
__________ Operator Average Skills Practice Sheet Appendix 3.4
Averages Challenge Assignment Appendix 3.5
Post-Assessment Appendix 3.6
Calculators

ADDITIONAL RESOURCES:

Basic Essentials of Math Book 1 (Steck-Vaughn) p. 35
GED Mathematics (Contemporary) p. 34-36
Number Power 1 (Contemporary) p. 126,127
Math Skills That Work (Contemporary) p. 165

Real Numbers: Tables, Graphs and Data Interpretation
(Contemporary) p. 51-54 and p. 60
Calculator Power (Contemporary) p. 68
Critical Thinking Skills With Math (Contemporary) p. 23
Variables Control Chart from Lesson 2, Appendix 2.2b or 2.2c

Have the students use their copy with the measurements already recorded. Students can find the averages of these sample measurements.

Vocabulary Sheet

Calculating Averages

(Appendix 3.1)

Average: The sum of a group of numbers divided by the number of numbers in that group. In SPC, the average is a number derived by dividing the sum of the measurement readings by the number of readings taken.

Mean: Synonym for average. Used often in SPC.

$\bar{X}$ (pronounced X bar): A symbol used to represent average or mean.

3-Step Method for Calculating Average:

1.

2.

3.

SAMPLE AVERAGE

SKILLS PRACTICE SHEET 1

(Appendix 3.2)

Calculate the sums ( ) and averages (X) of the following groups of numbers without using a calculator.

1. 31	24	22	36	37
32	24	21	33	38
+ 33	+ 21	+ 23	+ 39	+ 30
=	=	=	=	=
X=	X=	X=	X=	X=

2. 42	66	73	86	93
43	65	74	88	96
44	61	75	90	99
45	62	71	84	95
+ 41	+ 60	+ 76	+ 82	+ 91
=	=	=	=	=
X=	X=	X=	X=	X=

3. .27	.55	48.6
.28	.54	48.9
.26	.58	48.7
.25	.57	48.6
+ .29	+ .60	+ 48.5
=	=	=
X=	X=	X=

4. $.21 + .23 + .25 =$ $\overline{X}=$

$.47 + .40 + .45 =$ $\overline{X}=$

5. $22.23 + 22.20 + 22.21 + 22.20 + 22.22 =$ $\overline{X}=$

6. $67.15 + 67.17 + 67.16 + 67.14 + 67.16 =$ $\overline{X}=$

7. $122.50 + 122.55 + 122.53 + 122.54 =$ $\overline{X}=$

8. $9.832 + 9.839 + 9.836 + 9.835 + 9.837 =$ $\overline{X}=$

SAMPLE AVERAGE

SKILLS PRACTICE SHEET 2

(Appendix 3.3)

Use a calculator to find the following averages:

1.	65	52	812	635	925
	64	55	816	637	926
	67	56	818	634	928
	66	53	817	633	927
	+ 68	+ 54	+ 819	+ 632	+ 924
	=	=	=	=	=
	X=	X=	X=	X=	X=

2. 72.15 + 72.16 + 72.15 + 72.15 + 72.16 =
X=

3. 85.25 + 85.27 + 85.26 + 85.24 + 85.23 =
X=

4. 102.30 + 102.35 + 102.33 + 102.34 + 102.32 =
X=

5. 7.438 + 7.439 + 7.436 + 7.435 + 7.437 =
X=

________________ OPERATOR

AVERAGE SKILLS PRACTICE SHEET

(Appendix 3.4)

The following groups of numbers are sample measurements taken by __________ Operators.

Calculate the average of each group of numbers. Round your answers to one decimal place. The product is _____, with a specification of 172 +- 1mm.

	1.	2.	3.	4.
X1	171.5	171.7	172.4	170.7
X2	172.2	171.3	172.6	172.0
	=	=	=	=
	X=	X=	X=	X=

After you have calculated the averages, subtract the consigne width from the average. Record your answers below:

1.__________ 2.___________ 3.___________ 4.____________

Calculate the averages of the following groups of numbers. Round your answer to the nearest tenth. The product is_____. The specification is 138 +- 1mm.

	1.	2.	3.	4.
X1	137.3	138.0	137.6	136.8
X2	138.1	138.7	137.2	137.9
	$\bar{\bar{X}}$=	$\bar{\bar{X}}$=	$\bar{\bar{X}}$=	$\bar{\bar{X}}$=

After you calculate the averages, subtract the consigne width from the average. Record your answers below:

1.____________ 2.____________ 3.____________ 4.____________

CHALLENGE ASSIGNMENT

(Appendix 3.5)

Read the following scenario and answer the questions.

Operator 240 calculates averages often during her shift. She uses a calculator to do this. She records several groups of measurements. The product is____, with a specification of 138 +- 1mm. These are the averages that she calculates:

137.5	137.85	138.9	13.72	137.2
138.6	1.384	138.6	1328	137.21.

1. Should the operator question any of the averages she has calculated? yes no (circle your choice)
2. If so, circle the ones she should question.
3. What should she do if she gets an average that is not logical?

Post-Assessment

CALCULATING AVERAGES

(Appendix 3.5)

1. You have learned to write average 3 ways. Write average the 2 other ways you have learned.

   1.______________________________

   2.______________________________

2. In SPC, average is used to show the ______________________ of a process.

3. Write the steps used in calculating an average (3-step method).

1.____

____

2.____

____

3.____

____

4. Write the symbol for "sum of".

____

5. Calculate averages for the following:

1. 101.07	2. 2.424	3. 1.3512
101.05	2.425	1.3515
101.10	2.416	1.3526
101.06	2.420	1.3531
101.04	2.422	1.3515
=	=	=
$\bar{X}$=	$\bar{X}$=	$\bar{X}$=
Width: 101 +- 1mm	Width: 2.400 +- 1mm	Width: 1.3500+- 1mm

After you have calculated the averages, subtract the answer from the fictitious ______ width. Record your answer below:

1.________________ 2.________________ 3.________________

LESSON FOUR

CALCULATING RANGE

LINK OLD TO NEW:

During a previous lesson , the students learned how range is used in SPC. Discuss briefly. The size of the range is a rough indicator of the spread. It does not take onto account how far from the center each process is. The larger the range, the greater the variation in the product. Refer to the metric measurement lesson and explain that later in the lesson we will calculate the range of sample measurements like the ones taken in that lesson.

DIRECT INSTRUCTION 1:

Distribute the range example sheet (appendix 4.2).

The instructor will divide the class into groups. 5 or more pencils of varying lenghts will be handed to each group. Metric rulers will be distributed to each group. The group members measure the pencils and record the data. A group member will volunteer to record the measurements on the board for their group. Each group practices finding the smallest and largest measurement. Then each group calculates the range for their group of pencils using the 3-step method they created. After each group has found the range for their group of pencils, they can look at the data for the entire class and calculate the range for the group. Cover the following points about range: (Pass out the note sheet-appendix 4.3)

1. The range is the difference between the largest and smallest numbers in a group of numbers.
2. The size of the range is a rough indicator of the spread.
3. Range does not take into account how far from the center each process is.
4. The larger the range, the greater the variation in the product.
5. The smaller the range, the smaller the variation in the product.
6. Range is a value recorded and plotted on the SPC chart which we will do in lessons that follow.

POST-ASSESSMENT:

The instructor administers the post-assessment (appendix 4.7).

MATERIALS NEEDED:

Vocabulary Sheet Appendix 4.1
Range Example Sheet Appendix 4.2
Note Sheet Appendix 4.3
Range Skills Practice Sheet 1 Appendix 4.4
Range Skills Practice Sheet 2 Appendix 4.5
____ Operator Range Skills Practice Sheet Appendix 4.6
Post-Assessment Appendix 4.7
20-25 pencils of varying lengths
Overhead of Range Example Sheet
Calculators

ADDITIONAL RESOURCES:

Real Numbers: Tables, Graphs, and Data Interpretation
pages: 60, 61 question 62 (find the range for the scores in the column.)

Computer Software: Essentials of Statistical Process Control Lessons 2 and 3. Qualitran Professional Services Inc.

Vocabulary

(Appendix 4.1)

Range:

Symbol for Range:

3-Step Method:

1.

2.

3.

56

CALCULATING RANGE

EXAMPLE

(Appendix 4.2)

To calculate range:
Subtract the smallest number from the largest number.

EXAMPLE:

8	1. Identify the largest number	12
9	2. Identify the smallest number	- 8
10	3. Subtract the smallest number from the largest number.	4
11		
12	The range of this group of numbers is 4.	

PART B

Calculate the range for each group of numbers above. Record in the column titles RANGE. Use the space below to work the problems.

RANGE SKILLS

Practice Sheet 2

(Appendix 4.5)

Calculate ranges for the following groups of numbers:

Section 1:

1.	2.	3.	4.	5.
31	24	45	73	93
32	24	45	74	96
33	21	42	75	94
35	23	46	72	95
30	22	41	71	98
R=	R=	R=	R=	R=

6. 22.15, 22.17, 22.16, 22.14, 22.15 R=

7. 1.85, 1.86, 1.87, 1.88, 1.85 R=

8. 67.24, 67.25, 67.27, 67.26, 67.24 R=

9. 5.2506, 5.2508, 5.2511, 5.2509, 5.2507 R=

Section 2:

1.	2.	3.	4.	5.
65	52	812	635	925
64	55	816	637	926
67	56	818	634	928
66	53	817	633	927
68	54	819	633	924

6. 72.15, 72.16, 72.15, 72.17, 72.16 R=

7. 85.25, 85.27, 85.26, 85.24, 85.23 R=

8. 102.30, 102.35, 102.33, 102.34, 102.32 R=

9. 7.438, 7.439, 7.436, 7.435, 7.437 R=

OPERATOR

Range Skills Practice Sheet

(Appendix 4.6)

Calculate the range for the following measurements taken by each operator:

__________ Operator:

X1:	160.15	159.85	160.22	160.12	159.93	160.53
X2:	159.95	159.93	159.63	160.10	160.12	159.37
	R=	R=	R=	R=	R=	R=

X1:	159.75	159.37	160.56	161.00	160.25	160.63
X2:	160.12	160.82	159.32	159.82	159.75	160.63
	R=	R=	R=	R=	R=	R=

Operator:

Wt1:	.916	.941	.904	.919	.912	.927	.917	.903
Wt2:	.928	.935	.911	.918	.902	.914	.922	.916
Wt3:	.922	.936	.900	.917	.921	.926	.903	.905
Wt4:	.911	.931	.916	.920	.911	.908	.919	.923
	R=	R=	R=	R=	R=	R=	R=	R=

Operator:

Wt1:	172.5	175.8	171.7	173.0	174.8	176.0	172.6
Wt2:	170.6	172.6	176.2	172.8	170.3	174.8	172.7
	R=	R=	R=	R=	R=	R=	R=

Post-Assessment

CALCULATING RANGE

(Appendix 4.7)

In SPC, range is a very important calculation.
Answer these questions about range.

1. Write the symbol for range.________________

2. In SPC the range is calculated and plotted to determine

   ____.

3. Write the 3-step method for calculating range,

   1.

   2.

   3.

4. Calculate ranges for the following groups of numbers:

a. 25	b. 98	c. .935	d. 101.07	e. 2.424
32	95	.937	101.05	2.425
28	88	.940	101.10	2.416
22	93	.930	101.06	2.422
23	96	.938	101.04	2.421

LESSON FIVE

RECORDING AVERAGES AND RANGES

65

JOB TITLE: Operator
MODULE: Basic SPC Math
LESSON: Recording Average and Range on an SPC Chart

LEARNING OBJECTIVE:

Upon completion of the lesson, the student will be able to:

1. Record sum on the SPC chart.
2. Record average on the SPC chart with 100% accuracy.
3. Record range on the SPC chart with 100% accuracy.

SET INDUCTION:

The instructor distributes the "Reservation Scenario" (appendix 5.1).

Students read aloud or silently. The following questions can be used to start a discussion about the importance of recording information accurately:

1. What may have been the reason the receptionist recorded the information incorrectly? (list several reasons.)
2. What problems could the mistake have caused the receptionist?
3. What customer relation problems did it cause?
4. How could this situation be prevented?

PRE-TEACH VOCABULARY:

Review the definitions of average, range, and sum.

LINK OLD TO NEW:

In previous lessons students have learned to take measurements and weights, and record them on SPC charts. They have learned to calculate average and range. In this lesson, they will record measurements like these on SPC charts. They will also have more practice using the calculator to find average and range.

DIRECT INSTRUCTION 1:
The students have the variables control chart they used in Lesson 2 Recording Measurements (appendix 2.2b or c). They will calculate the range and average of these measurements as a review. The instructor may use the overlay transparency to demonstrate recording the sum, average and range for the first two groups of sample measure-ments.

GUIDED INSTRUCTION 1 :
Students calculate average and range of the next two measurements and record them on the SPC chart. The instructor checks for accuracy.

INDEPENDENT INSTRUCTION 1:
The students complete the remaining calculations and record the answers. They have their work checked.

DIRECT INSTRUCTION 2:
The instructor distributes the__________ Operator Control Chart (appendix 5.2) and demonstrates how to record the average. The average is not recorded directly. First, the consigne width must be subtracted from the average. The students practiced this in Lesson 3, Calculating averages. This is the value they record on the chart. They calculate the range of these measurements and record them on the control chart.

GUIDED INSTRUCTION 2:
The students will use the averages they calculated in Lesson 3, Appendix 3.4, page 44, to record on the control chart. They record the first one and the instructor goes over the answer. They calculate the range and record it. The instructor checks their work.

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INDEPENDENT PRACTICE 2:
The students record the remaining averages, calculate the ranges, and record them, also. The instructor checks their work.

POST-ASSESSMENT:
The instructor administers the post-assessment.

MATERIALS NEEDED:
Overlay transparency of the variables control chart
"Reservation Scenario" Appendix 5.1
Variables control chart from Lesson 2 Apendix 2.2b or 2.2c
__________ Operator Average Skills Practice Sheet from
Lesson 3 Appendix 3.4
________________ Control Chart Appendix 5.2

RECORDING AVERAGES AND RANGES

Reservation Scenario

(Appendix 5.1)

A receptionist at Fun in the Sun Beach Resort in Panama City Beach, Florida, was taking reservations by phone from Mr. Smith. Mr. Smith couldn't wait to leave Ontario and head south. He requested a room for 3 nights, beginning March 29th. He planned to check out on April 1st. Another call interrupts their conversation and the receptionist puts Mr. Smith on hold. The second caller requests reservations for March 30th. When the receptionist gets back to Mr. Smith, she puts his reservation date into the computer. She is confused by the second call and records his arrival date as March 30th.

Mr. and Mrs. Smith arrive on the 29th and attempt to check in. They are told they don't have a reservation for the 29th. Their arrival date appears on the computer screen as the 30th. It's Spring Break and there are no other rooms available. Mr. Smith is hoping this is an early April Fool's joke, but nobody's laughing. Mr. Smith remembers he has the reservation dates and confirmation number in his Franklin Planner so he can prove he made the reservation for the 29th. The receptionist must find a suitable alternative for an irrate Mr. Smith.

Discuss the following questions:

1. Why do you think the receptionist made the mistake?
2. How did the situation affect the customer?
3. How do yu thinkk it affected the receptionist?
4. What could she do to make sure it doesn't happen again?
5. How important is it to record information correctly?
6. Think of ways that you record information on your job. What could happen if a mistake is made?

MICHELIN US4 SPC CHART

MACHINE:

CHARACTERISTIC: WIDTH

MEASURING INSTRUMENT: DIGITAL CALIPER

START-UP ZONE: +/- 0.07 M

SPECIFICATION: +/- 1.00 M

DATE

PRODUCT

TICKET #

OPERATOR

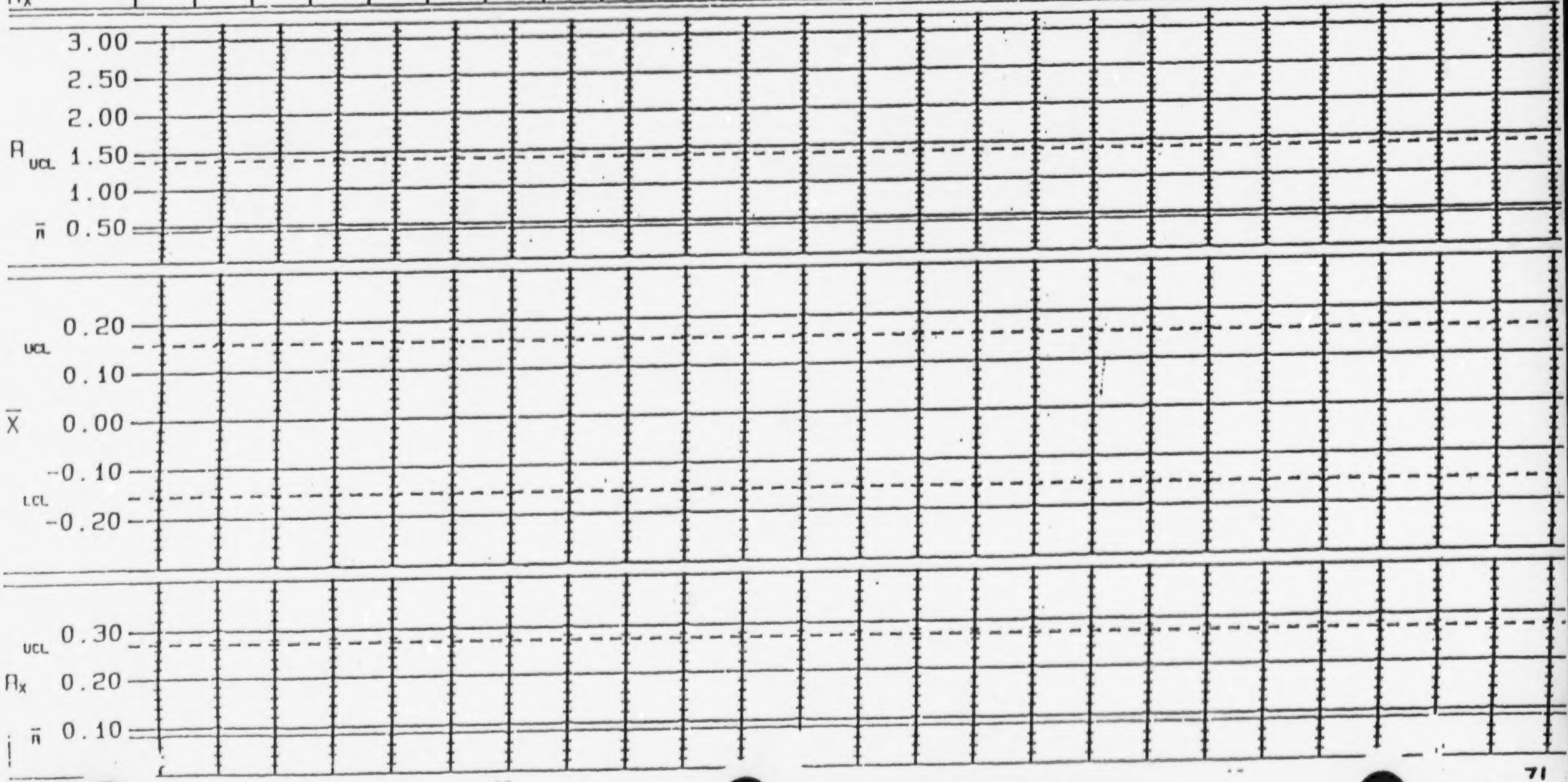
X_1

X_2

R

$\overline{X}$

R_x



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LESSON SIX

PLOTTING AVERAGE AND RANGE

JOB TITLE: _____ Operator
MODULE: Basic SPC Math
LESSON: Plotting Average and Range on an SPC Chart

LEARNING OBJECTIVES:

Upon completion of the lesson, the student will be able to:

1. Plot average on an SPC chart.
2. Plot range on an SPC chart.

SET INDUCTION:

Divide students into groups. Give each group a copy of a different line graph (references listed under materials needed) Distribute the Question sheet (appendix 6.1). Students discuss the answers to the questions on the sheet. One member of the group will present the results of the discussion and explain the graph.

PRE-TEACH VOCABULARY:

Line Graph
Horizontal Grid Lines
Vertical Grid Lines
Connecting Points
Plotting Points
Upper Control Limit UCL
Lower Control Limit LCL

Using the line graphs from the set induction exercise, discuss each vocabluary word. Distribute the contol chart and show students how to label each part of the graph (appendix 6.2).

LINK OLD TO NEW:

The students have measured samples for SPC, recorded them on control charts, learned to calclate average and range and record them on control charts. Now, they will plot the average and range on control charts and connect the points.

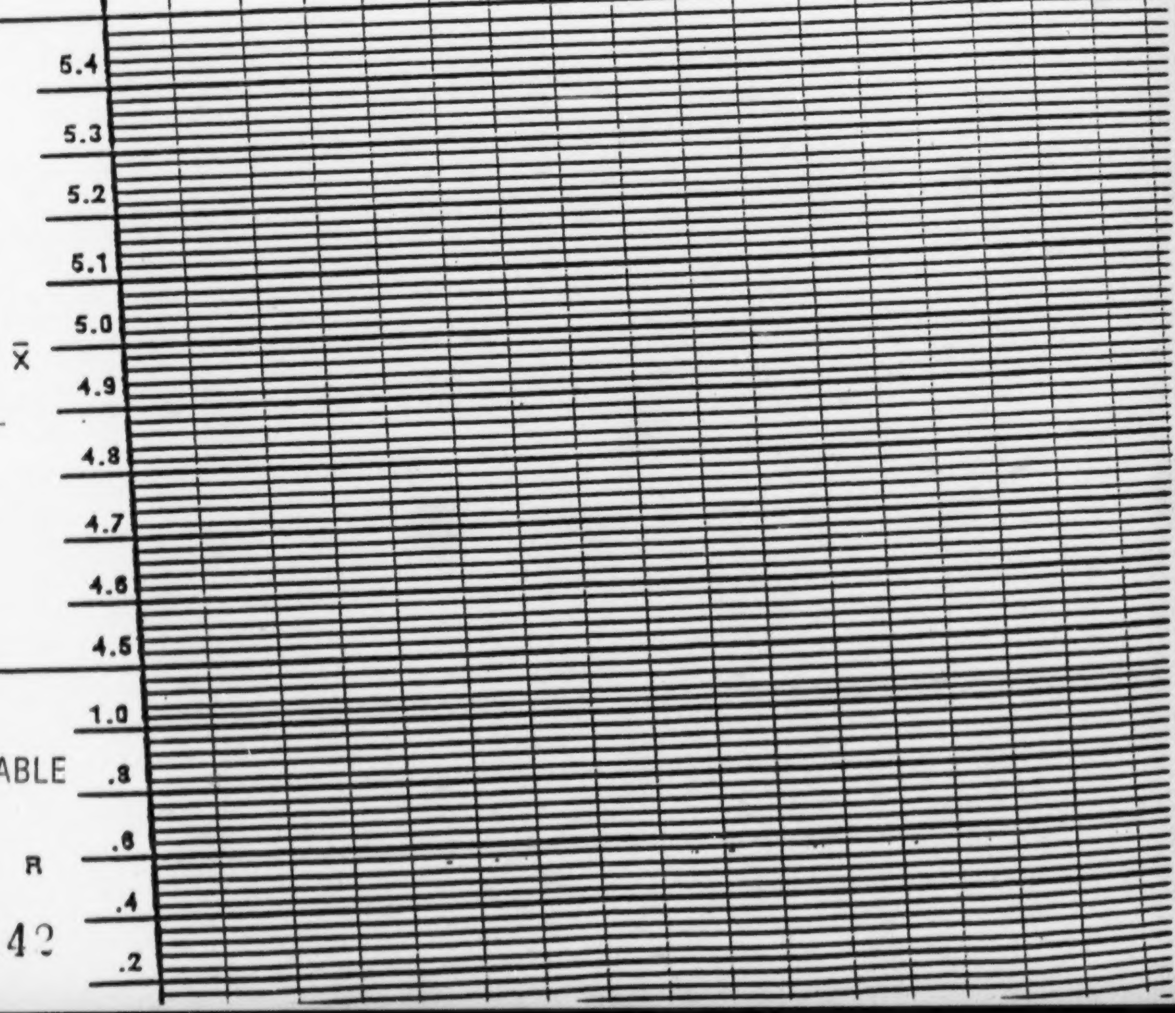
ARTICLE FABRICATION

VARIABLES CONTROL CHART

$\bar{X}$ AND R

ARTICLE	PROJECT NO. 705	OPERATOR(S)
SPECIFICATION LIMITS 5 $^{-0.5}_{+0.5}$	UNIT OF MEASURE MM	CHART START DATE

SAMPLE VALUES																		
1																		
2																		
3																		
4																		
SUM																		
$\bar{X}$																		
R																		
SAMPLE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
COMMENTS																		



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DIRECT INSTRUCTION 1:
The instructor reviews the definition of a line graph and covers the following general facts about line graphs:
It is the most widely used graph because:

1. It is easy to make.
2. It presents facts clearly.
3. It is simple to interpret.
4. It uses lines to show patterns or trends.
5. It is useful for comparing changes in amounts.
6. It provides information for comparing changes without having to do further computations.

The instructor can distribute the note sheet (appendix 6.3). Students may add their own notes to the sheet, as the lesson continues.

Next, the instructor discusses how to read a line graph. Refer to Real Numbers: Tables, Graphs, and Data Interpretation, pages 35 and 36.

GUIDED PRACTICE 1:
Work through page 35 with the students.

INDEPENDENT PRACTICE 1:
Students work page 36 on their own and have their answers checked.

DIRECT INSTRUCTION 2:
Next, discuss plotting points on a line graph. Refer to Real Numbers: Tables, Graphs, and Data Interpretation pages 37-39. Explain using page 37. Work through this page with the students.

The instructor works page 38 with the students assisting individually those who need help. They check their work.

INDEPENDENT PRACTICE 2:
The students work page 39, independently, then have their work checked.

DIRECT INSTRUCTION 3:
The instructor uses the variables control chart from Lesson 5, Recording Average and Range, to explain plotting on an SPC Chart (appendix 6.4). If the students do not have their copy from that lesson, have copies available for them. Plot several points on the graph with the students.

GUIDED INSTRUCTION 3:
The students plot the next 3 points on the graph and the instructor goes over them.

INDEPENDENT PRACTICE 3:
The students plot the remaining points and the instructor will check them. The students connect the points on the graph.

DIRECT INSTRUCTION 4:
After the students have completed the graphing, the teacher discusses how to interpret the graph. The instructor distributes the __________ Operator Control Chart (appendix 6.5) with averges and ranges recorded.

INDEPENDENT PRACTICE 4:
The students plot the averages and ranges on the graph, connect the points, and a discussion follows about how to interpret it.

POST-ASSESSMENT:
The instructor administers the post assessment (appendix 6.6).

POST-ASSESSMENT:

The instructor administers the post assessment (appendix 6.6).

MATERIALS NEEDED:

Set Induction Question Sheet Appendix 6.1
Variables Control Chart Appendix 6.2
Note Sheet Appendix 6.3
Variables Control Chart with averages and ranges recorded Appendix 6.4
__________ Operator Control Chart with averages and ranges recorded Appendix 6.5
Post- Assessment Appendix 6.6

ADDITIONAL RESOURCES:

Computer Software: Essentials of Statistical Process Control Lessons 2 and 3. Qualitran Professional Services Inc.

LINE GRAPH

Question Sheet

(Appendix 6.1)

Using the line graph, answer the following questions.

1. What is the title of the graph?

2. What does the horizontal axis measure?

3. What does the vertical axis measure?

4. What do the points that are plotted measure?

5. Make a summary statement about your graph.

Notes

Line Graphs

(Appendix 6.3)

Line Graphs are the most widely used graph because:

1. They are easy to make.
2. They present facts clearly.
3. They are simple to interpret.
4. They use lines to show patterns or trends.
5. They are useful for comparing changes in amounts.
6. They provide information for comparing changes without having to do further computations.

Add your notes:

Appendix 6.4

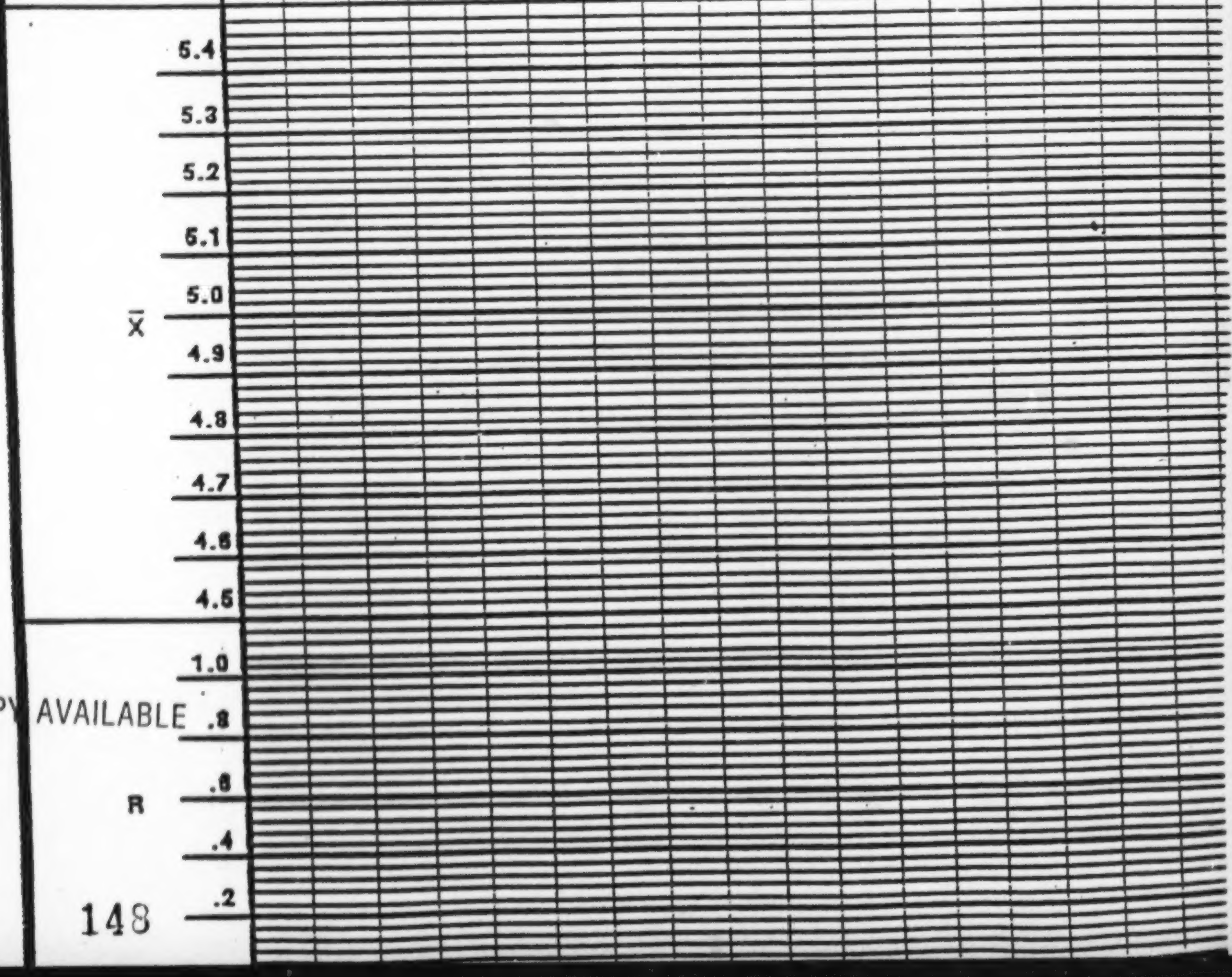
ARTICLE FABRICATION

VARIABLES CONTROL CHART

X̄ AND R

ARTICLE	PROJECT NO. 705	OPERATOR(S)	
SPECIFICATION LIMITS	5 −0.5 +0.5	UNIT OF MEASURE MM	CHART START DATE

SAMPLE VALUES	1	4.9	5.0	5.0	5.1	5.0	5.1	5.1	4.9	4.9	5.1								
	2	4.8	5.1	5.0	4.8	5.1	5.0	5.0	5.0	5.0	4.9								
	3	5.0	4.9	4.9	4.9	5.1	5.0	5.0	5.0	5.1	4.8								
	4	4.8	5.0	5.0	5.0	5.1	4.9	4.9	4.9	5.1	4.8								
	SUM	19.5	20.0	19.9	19.8	20.3	20.0	20.0	19.8	20.1	19.6								
	$\bar{X}$	4.88	5.0	4.98	4.95	5.08	5.0	5.0	4.95	5.03	4.90								
	R	0.2	0.2	0.1	0.3	0.1	0.2	0.2	0.1	0.2	0.3								
SAMPLE NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
COMMENTS																			



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Post-Assessment

PLOTTING AVERAGES & RANGES

(Appendix 6.6)

The measurements have been recorded on the variables control chart. You will need to:

1. Calculate the average and the range.
2. Plot the points on the graph and connect them.
3. Tell whether or not the process is stable.

BASIC SPC MATH

Pre and Post Assessment

DIRECTIONS: Work as many of the following problems as you can. Do not use your calculator .

ADDITION: Add the following groups of numbers.

1. 70.1
70.4
70.6
70.2
+ 69.8

2. 2.523
2.521
2.522
2.530
+ 2.521

3. .0496
.0488
.0489
.0494
+ .0492

SUBTRACTION: Subtract the following numbers.

4. 61.5
- 59.7

5. 1.530
- 1.521

6. .0497
- .0488

MULTIPLICATION: Multiply the following numbers.

7. 240.5
x 5

8. 760
x 7

9. .0269
x 6

AVERAGE: Find the sum of each group of numbers. Then, find the average of each group of numbers.

10. 102.06
102.10
102.05
102.04
102.00
=
X =

11. 3.325
3.322
3.316
3.320
3.322
=
X =

12. 1.4621
1.4626
1.4623
1.4619
1.4625
=
X =

RANGE: Calculate the range of each group of numbers.

13. 3.425
3.422
3.418
3.420
3.422
R=

14. 70.1
70.4
70.6
70.8
69.8
R=

15. .0496
.0488
.0489
.0494
.0492
R=

16. Write a synonym for the word average: ____________________

17. Write the symbol for the word average: ____________________

18. Write the symbol for "sum of": ____________________

19. Write the symbol for range: ____________________

On the blank variables control chart, record the following information:

20. Write your name in the blank labeled "operator".
21. Write today's date for the "chart start date".
22. Record the measurements below in the appropriate spaces.

Sample 1: 4.8 4.8 5.0 5.1 4.9 5.1 4.8 5.0
Sample 2: 5.0 4.8 5.0 5.1 5.0 5.0 4.9 4.8
Sample 3: 4.9 5.1 5.0 5.0 4.9 5.0 5.0 5.1
Sample 4: 5.1 4.9 5.0 5.1 5.0 4.9 5.1 5.0

23. Find the sum of the measurements recorded in number 3.
24. Find the average of the measurements recorded in number 3.
25. Find the range of the measurements recorded in number 3.
26. Plot the average on the graph.
27. Connect the points.
28. Plot the range on the graph.
29. Connect the points.

30. List 3 causes of inaccurate measurement

1. ____
____.

2. ____
____.

3. ____
____.

31. List 3 ways to ensure accurate recording.

1. ____.

2. ____.

3. ____.

32. Why is SPC used at Michelin?

____.

GUIDED PRACTICE 1:

Use several more examples of calculating range from the following suggestions or use suggestions from the class. Find the range of a group of sample test scores, or the range of a group of prices for tires. Use the references for additional assignments at the end of the lesson if needed. Be sure to use whole nember and decimal nember examples. Discuss and check each problem.

INDEPENDENT PRACTICE 1:

Distribute the Range Skills Practice Sheet 1 (appendix 4.4). Give the students time to work on the sheet, then check their answers.

GUIDED PRACTICE 2:

Distribute calculators. Demonstrate finding range using a calculator. Distribute the Range Skills Practice Sheet 2 (appendix 4.5). Work section one of the sheet and check.

INDEPENDENT PRACTICE 2:

Students work the problems in section 2 independently, using a calculator and check answers.

GUIDED PRACTICE 3:

The instructor will review the differences in sampling techniques, if necessary. Distribute the ____ Operator's Range Skills Practice Sheet (appendix 4.6). Explain that we will be using measurements like the ones taken in the metric measurement lesson calculate range. The instructor works several problems from the sheet with the students and check their answers. They may use a calculator.